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Assessing the total factor productivity changes by the DEA-based Malmquist productivity approach: Evidence from banks of MENA region

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Abstract: The aim of this study is to assess the productivity change of the banks of the MENA region using a DEA-based Malmquist productivity index approach. For this purpose, we apply the model separately on59 conventional banks and22 Islamic banks. Concerning the conventional banks, the results show that they have recorded a slight productivity progress over the study period with an increase of 0,1%, due mainly to a technological progress with an increase of 0,4%; they have registered the highest average productivity increase in 2019-2020 with a growth of 3,2% and the highest regression in 2018-2019 with a decline of 1,7%. Over the period 2017-2021, we find that one bank of Egypt has registered the highest productivity increase with an increase of 19,7%, due mainly to technological progress, and one bank of Kuwait has registered the highest productivity decline with a regression of 24,9%. We also obtain that over the study period, 51% of conventional banks has recorded a productivity progression; the Banks of Egypt have registered on average the highest productivity progress with an increase of 3,3%, due mainly to a technological progress; the banks of Kuwait have recorded the highest productivity decline with a regression of 5,9%. Concerning the Islamic banks, the results show that over the study period, they have on average recorded a productivity decline with a regression of 0,9%;they have registered on average the highest productivity increase in the period 2019-2020 with an increase of 8,9%; the highest regression with a decline of 1,7%. We also find that over the study period one Islamic bank of Oman has registered the highest productivity increase with a progression of 36,9% and one Islamic bank of Morocco has registered the highest productivity decline with a regression of 36,3%. Other results show that 64% of Islamic banks has recorded a productivity progress over the study period and the banks of Oman have registered the highest productivity progress with an increase of 36,39%; while the banks of Morocco have recorded the highest productivity decline with a regression of 15,3%, due mainly to technological regression and efficiency scale decline.

Keywords: DEA-based Malmquist approach, Total Factor Productivity change, technical efficiency change, Pure technical efficiency change, Efficiency scale change, Technological change, Distance

1. Introduction

Banking system plays a vital role in the development and growth of modern economies, by providing funds for investors in need from savers with excess funds. Banks in MENA region, as intermediary financial institutions for the economy, face intense challenges of globalization and competition. Therefore, they are obliged to use their resources efficiently for providing quality products and services to operate long lastingly and survive in a high level of competitiveness conditions. They must use specific tools to measure their productivity changes over time to give confidence to bank shareholders, investors as well as to their customers.

The present study has the aim to analyze the productivity changes of the Middle East and Nort Africa (MENA) banking sector during the period 2017-2021. For this purpose, Malmquist Productivity Index (MPI) based on Data Envelopment Analysis (DEA) was used. DEA-MPI estimates the change of total factor productivity (TFP), which can be decomposed into technical efficiency change and technology change. Further, technical efficiency can also be splitted into pure technical efficiency change and scale efficiency change. To the best of our knowledge, this is the first study that apply the DEA-based Malmquist Total Factor Approach to a fairly large number of both conventional and Islamic banks operating in the MENA region.

The background of Malmquist Total Factor Productivity began in the year 1953, when the Swedish economist Malmquist(1953) introduced a quantity index as the ratio of distance functions. Then Caves, Christensen and Diewert(1982), referring to the original paper of Malmquist(1953), introduced the earliest type of the Malmquist index. They named their proposed productivity index in the name of Malmquist. They defined the Malmquist total productivity change index using input and output distance functions as given by Malmquist. This index can be constructed by evaluating the distance of the production unit defined by input and output vectors for two time periods, in terms of a referred technology. As the distances can be either output-oriented or input-oriented, the Malmquist TFP indices differ according to the orientation used (Coelliet al. (2005)). The output-oriented productivity focuses on the maximum level of outputs that can be produced using a given input vector and a given production technology relative to the observed level of outputs. The input-oriented productivity focuses on the level of inputs necessary to produce given output vectors, under a reference technology.

Note that Caves et al. (1982) had introduced Malmquist index as a theoretical index, whereas Fare et al.(1989) calculated the Malmquist index directly by exploiting the fact that the distance functions on which the Malmquist index is based can be calculated by using mathematical linear programs of the technical-efficiency measures developed by Farrell (1957).More precisely, Fare et al. (1989) made use of the relation between Farell's measures of technical efficiency introduced by Farrell(1957), Data Envelopment Analysis (DEA) developed by Charnes et al. (1978) and Malmquist productivity index initiated by Caves et al. (1982) to introduce the DEA estimation method for the Malmquist productivity index (DEA-MPI).

Furthermore, Färeet al. (1992) had proved that the DEA-MPI could be decomposed into efficiency change index and technical change index. Fareet al. (1994) decomposed efficiency change into pure technical efficiency change and scale efficiency change, which has made the Malmquist index widely popular as an empirical index of productivity change.

The rest of the paper is organized as follows. Section 2 provides the literature review related to the application of DEA-Malmquist productivity index to banking sector. Section 3 describes the data employed and presents the methodology of the current study. Section 4 presents the empirical results of the study. We conclude by the section 5.

2. Literature review

This section is devoted to the literature review of studies related to the DEA based Malmquist Total Factor Productivity method. Various studies have applied DEA-MPI to determine the productivity change of production units belonging to diverse domains over a certain period of time. Likewise, in the banking sector, several researchers have applied the DEA-MPI to measure the change in productivity of banks between two periods.

In Europe, Malmquist Productivity Index (MPI) was first applied by Berger et al. (1992) to Norwegian banksto evaluate the impact of deregulation in the banking sector. Their empirical results proved a productivity deterioration prior to deregulation and at post deregulation the Norwegian banking system had experienced improvement in productivity.

Chansarn (2014) evaluated the productivity change of 14 Thai banks over the period of 2000-2009. Their findings had suggested that the productivity seemed to be low during the period of study; the banks had recorded an average productivity change of -13.35% to 10.06%. Furthermore, the results showed that an average negative productivity growth was registered by most of the Thai banks.

Thayaparan and Pratheepan (2014) assessed the productivity change of the Sri Lankan banking sector over the period of 2009-2012 by using an output-oriented DEA-MPI. Their findings demonstrated that the productivity change of all the banks had decreased due to technical deterioration. Moreover, the study proved that the impact of technical change on the productivity of the Sri Lankan banks was high comparing to efficiency change. They also found that the efficiency of private-owned banks was larger than their counterparts.

Baten et al. (2015) evaluated the efficiency and total factor productivity changes of the Bangladesh banking sector by applying DEA-MPI. Their results proved that state-owned banks experienced the highest cost inefficiency and profit efficiency in comparison to the private banks. Furthermore, the average technical and allocative efficiency had reached 75.4% and 35.9%, 74.0% and 31.8% for the cost DEA and the profit DEA respectively for the two type banks.

Muvingi and Hotera (2015) measured the technical efficiency and total factor productivity of 10 Zimbabwean banks over the period 2002-2012 using DEA-MPI. Their findings proved that the banks had an average technical efficiency of 70.95% and 81.5% under CRS and VRS respectively. Also, the average scale efficiency of the banks had reached a score of 73.7% per annum.

Isik et al. (2016) evaluated the productivity change of the Jordan commercial banks as a middle east economy by using DEA and input-oriented Malmquist productivity index. Their empirical results proved that the technological change under the production (intermediation) approach was 0% (0.7%) for commercial banks, 1.8% (4.3%) for investment banks and -4.7% (-2.7%) for Islamic banks, while the technical efficiency change under the production (intermediation) approach was 6.5% (1%) for commercial banks, 1.8% (2.8%) for investment banks and -9% (-5%) for Islamic banks.

Jreisat and Hassan (2016) assessed the productivity growth of 14 Egyptian commercial banks over the period 1997-2013 by applying DEA-MPI. Their results showed that the productivity growth of the 14 banks had declined at the rate of 2.55% over the study period.

Garamu (2016) measured the technical efficiency and the productivity change of the Ethiopian banks by using a DEA-MP Iover the period 2007-2011. The results showed that the banks' TFP performance had decreased with a value of 0.956% due mainly to technical efficiency change which regressed by 0.629%.

Lera and Rao (2016) assessed the productivity change of the Ethiopian commercial banks by applying a DEA-MPI. Their results showed that the banks registered a TFP improvement due to the progress in technological change.

Lema (2016) analyzed the productivity change of the Ethiopian banking industry by applying a DEA-MPI from 2011 to 2014. Their results showed that the banks recorded a TFP progress of 1.038% due mainly to progress in the technical change of 1.042% while the industry registered a technical efficiency change of 0.996% during the study period.

Reshampal and Aggarwal (2017) assessed the productivity change of 25 public sector banks operating in India from the year 1998 to 2013 by employing DEA-MPI. Their results suggested that out of 25 public sector banks under study, 20% banks registered a decrease in overall TFP, whereas 80% banks recoded positive growth in TFP. They found that technological changes had largely contributed to growth of TFP of the public sector banks.

Varesi (2015) assessed the productivity change of16 Albanian banks, for the period 2008-2013 by applying the DEA-MP. The results demonstrated that medium and small banks are more productive than the large banks.

Tadesse (2016) assessed the productivity change of 16 private owned banks and 3 government owned banks of Ethiopia over the period 2011-2014 by employing DEA-MPI. Their results of the study confirmed that Abay bank, Construction and Business Bank and Commercial Bank of Ethiopia registered a productivity regress due to technical change for the first bank and to efficiency change for the other banks. They found also that Construction and Business bank and United bank recorded productivity regress in the pure technical efficiency component while Construction and Business bank, Commercial bank of Ethiopia, Nib international bank and Wegagen bank registered productivity regress in the scale efficiency change component.

Irini (2018) evaluated the productivity change of 16 Albanian banks over the period 2006-2017 by applying the DEA-MPI. Th results proved that Albanian banks had registered a decrease inproductivity due mainly to the technical decline. Furthermore, efficiency had improved during the period of study due to progress in pure efficiency and scale efficiency. They also found that the medium size banks had registered a TFP increase, compared to large and small banks.

Basri et al. (2018) measured the productivity change of 16 Malaysian Islamic banks from 2008 to 2015 by employing the DEA-MPI. Their findings showed that domestic Islamic banks are more efficient than foreign Islamic banks. Moreover, they found that the least efficient banks had improved in technical efficiency, technology, and total factor productivity.

Shahet al. (2019) assessed the efficiency and productivity change of 33 sustainable banks and 247 non-sustainable banks for 9 years period 2010–2018 by using the DEA-MPI. Their results revealed that sustainable banks are more efficient and productive than non-sustainable banks. Moreover, the productivity of sustainable banks and non-sustainable banks was influenced by external and internal factors.

Alexakiset al. (2019) assessed the efficiency and productivity change of Islamic and conventional banks of the GCC region over the 2006–2012 period that covers the global financial crisis by using financial ratios and meta-frontier Malmquist productivity index. Their results showed that Islamic banks had exhibited worse cost and profit performance but were on a par with regards to revenue performance compared to the conventional ones. They found also that the technology of conventional banks had improved markedly in years leading to the financial crisis and declines thereafter. Overall, the results suggested that the two bank types are more aligned following the global financial crisis.

Jubileeet al. (2020) evaluated the productivity change of 385 Islamic and conventional banks 18 countries of the Middle East, Southeast Asia and South Asia for the period from 2008 to 2017 by using the DEA-PMI. Their results suggested that Islamic banks are more productive than conventional banks, and the productivity progress is due to efficiency increase.

Otaviya and Rani (2020) evaluated the productivity change of Indonesian Islamic banks during the period 2011-2018 using the DEA-MPI. Their results showed that Indonesian Islamic banks had registered productivity growth in the period of study, due mainly to technical et technological changes.

Aasri and Lkoyaali (2021) assessed the efficiency of Moroccan banks over the period 2017-2019 by using an input-orientation and VRS DEA-MPI. The results proved that the average efficiency of all banks had changed over the study period, but the scores had registered remain low and had showed a serious inefficiency. They also proved that the average improvement of TFP is not due to technological innovation, but rather to scale efficiency and pure efficiency changes. Moreover, the total productivity had not improved significantly throughout this period.

Laporšek et al. (2022) evaluated the productivity change of a balanced panel of 1915 European banks banks during the 2013–2018 post-crisis period applying DEA-MPI. Their results showed that the overall MPI of banks had a modest increase in half of the EU countries due mainly to mainly to technological improvement, which was particularly high among the new EU member states, whereas there was a significant decline in technical efficiency.

3. Data and methodology

The main purpose of this study is to measure the productivity change of the MENA region's banks. Below, we present the data and describe the methodology.

3.1 Data Type and Sources of Data

For the sake of arriving at our aim, we use a balanced panel data of 81banks operating over the period 2017-2021 in the MENA (Middle East and North Africa) region. We divide these banks into two classes, the class of conventional banks comprising 59 banks and the class of Islamic banks comprising 22 banks. We have included only banks and countries for which data is available. The inputs and outputs used to evaluate the productivity change of the banks was collected from the annual balance sheet and financial statements of the respective banks.

The productivity changes of the banks of the two classes are assessed separately by using an output-oriented DEA-based Malmquist productivity index under the constant scale returns.

3.2 Input-Output Variables for the DEA Model

It is vital to appropriately define the input-output variables to assess the productivity change of the banks. Intermediation approach and production approach are the two most important approaches used to identify these variables. In this study we choose the intermediation approach to specify the inputs and output variables. In this approach, the outputs measure the desired outcome or revenue of banks (measured in dollars) while the inputs represent resources (measured in dollars) used to operate the banks.

The suitable number of input-output variables is determined by meeting there commended assumption prior to performing DEA (Cooper et al. (2002)):

$$N \geq Max\big(I \times J, 3(I + I)\big) \quad (1)$$

Where:

$N =$ Number of $DMUs$; $I =$ Number of inputs ; $J =$ Number of outputs.

In this study we specify three inputs (Total liabilities, Operating expenses including employees' expenses, Depreciation and amortization of tangible fixed assets) and two outputs (Operating income, Total assets except tangible fixed assets), which are depicted in the table 1 below:

Table 1: Input and output variables

Input 1	**Input 2**	**Input 3**	**Output 1**	**Output 2**
Total liabilities	Operating expenses	Depreciation and amortization	Total assets except tangible fixed assets	Operating income

Tables 2 and 3 below show respectively the 59 conventional and 22 Islamic banks.

Table 2: 59conventional banks of 11 MENA region countries

Country	N°	Bank	Country	N°	Bank
Bahrain	1	Ahli United Bank	Lebanon	30	Bank Audi
	2	Alubaf Arab International Bank		31	Bank of Beirout
	3	Arab Banking Corporation		32	Crédit Libanais
Algeria	4	BNP Paribas Al-djazair		33	Saradar Bank
	5	Fransabank El Djazaïr SPA	Morocco	34	Al Barid Bank
	6	Société générale Algérie		35	Attijariwafa Bank
United Arab Emirates	7	Abu Dhabi Commercial Bank		36	Bank of Africa
	8	Bank of Sharjah		37	Banque Centrale Populaire
	9	Commercial Bank of Dubai		38	Banque marocaine pour le commerce et l'industrie
	10	Emirates NBD		39	Crédit Agricole du Maroc
	11	First Abu Dhabi Bank		40	Crédit Immobilier et Hôtelier
	12	National Bank of Fujairah		41	Crédit du Maroc
	13	National Bank of Ras Al Khaimah		42	Société générale Maroc
	14	National Bank of Umm Al Qaiwain		43	CaixaBank Casablanca
	15	United Arab Bank		44	CDG Capital
Egypt	16	Bank of Alexandria		45	CFG Bank
	17	Banque du Caire		46	CITIBANK Maghreb
	18	Commercial International Bank	Oman	47	Bank Dhofar
	19	HSBC Bank Egypt S.A.E.		48	Bank Muscat
Jordan	20	Arab Jordan Investment Bank		49	Oman Arab Bank
	21	Bank of Jordan	Qatar	50	Ahli Bank
	22	Capital Bank of Jordan		51	Commercial Bank of Qatar
	23	Jordan Ahli Bank		52	Doha bank
	24	Jordan Commercial Bank	Tunisia	53	Bank ABC tunisia
Kuwait	25	Al Ahli Bank of Kuwait		54	Amen Bank
	26	Burgan Bank		55	Banque de Tunisie
	27	Commercial Bank of Kuwait		56	Banque internationale arabe de Tunisie
	28	Gulf Bank		57	Banque Tunisie arabe
	29	National Bank of Kuwait		58	Société Tunisienne de Banque
				59	Tunisian Saudi Bank

Table 3: 22 Islamic banks of 7 countries MENA region

Country	N°	Bank	Country	N°	Bank
Bahrain	1	Al Salam Bank	United Arab Emirates	12	Ajman Bank
	2	Bahrain Islamic Bank		13	Al Hilal Bank
Saudi Arabia	3	Bank Aljazira		14	Dubai Islamic Bank
	4	Al Rajhi bank	Morocco	15	Al Akhdar Bank
	5	Alimna Bank		16	Bank Assafa
	6	Arab National Bank		17	Umina bank
	7	Bank Al Bilad	Oman	18	Alizz Islamic Bank
	8	Banque Britannique Saoudienne	Qatar	19	Masraf Al Rayan bank
	9	Banque Saudi Fransi		20	Qatar Islamic Bank
	10	National Commercial Bank ou Saudi National Bank	Tunisia	21	Banque Al-Baraka Tunisie
	11	Ryad Bank		22	Banque Zitouna

3.3 Methodology: DEA based Malmquist Total Factor Productivity Index (DEA-MPI)

The assessment of efficiency and how efficiency changes over a specific period is an important issue for financial institutions. However, we observe that efficiency analysis is static and does not take into consideration time dimension. Whereas productivity change refers to a change in the productivity of a production unit from one period to another. When time is involved in the analysis of productivity change, we need to consider the concept of change in technology. Technological change is defined as the shift of the production frontier determined by the technology in the corresponding time periods. A change in the productivity of a DMU overtime may be caused not only by a change in its efficiency, but also by a change in its technology or scale efficiency or by a combination of these two factors. The Total Factor Productivity (TFP) could be calculated with several methods as Fisher Price Index, Törnqvist index which is attributed to Törnqvist (1936)and Malmquist TFP Index. The advantage of Malmquist TFP Index can be summarized as:

- ✓ It does not use cost minimization or profit maximization assumptions (it does not require any price data).
- ✓ It defines explicitly two components of the index, change technical efficiency and change in technology.

There are two main methods to evaluate the change in TFP. The first one is the nonparametric DEA method which is a linear programming method, and the second one is the parametric SFA (stochastic frontier analysis) method which use econometric methods. Malmquist TFP Index was first introduced by Caveset al. (1982). This index is constructed using the ratios of distance functions which were earlier used to construct quantity indexes by Malmquist (1953). Thereby, the resulting index is called Malmquist TFP index.

Malmquist TFP Index estimates the change in productivity between two periods by calculating the radial distance of input-output combinations to the production frontier at a given period or in other words relative to a reference technology. The radial distance measurements can be input-oriented or output-oriented which cause a difference in orientation of Malmquist indices. Technologies with multiple-output and multiple-input can be represented by distance functions which only require data of input and output values.

The distance function can be presented as an input distance function or an output distance function. An input distance function describes the production technology by looking at a minimal proportional decrease of the input vector, given an output vector. An output distance function using the given input vector describes a maximal proportional increase of the output vector. In the present study, the Malmquist productivity index will be defined using the output distance function.

As presented in the study of Färe et al. (1994), we denote by $S^t$the production technology (or production possibility) set for each period$t = 1, \cdots, T$, which also represents the transformation of input vector$X^t$to output vectorY^t:

$$S^t = \{(X^t, Y^t)/X^t \ produce\ Y^t\} \qquad (2)$$

We suppose that we have N data making unitsDMU_n, for $1 \le n \le N$. At any date$t = 1, \cdots, T$, eachDMU_n, consumes I inputs x_{in}^t for $1 \le i \le I$ and produces J outputs, y_{jn}^t for $1 \le j \le J$.We define the input and output vectors by:

$$X_n^t = \begin{pmatrix} x_{1n}^t \\ x_{2n}^t \\ \vdots \\ x_{In}^t \end{pmatrix},\ Y_n^t = \begin{pmatrix} y_{1n}^t \\ y_{2n}^t \\ \vdots \\ y_{Jn}^t \end{pmatrix} \qquad (3)$$

The input and output vectors can be grouped into two matrices:

$$X^t = (X_1^t \quad \cdots \quad X_N^t) = (x_{In}^t)_{\substack{1 \le i \le I \\ 1 \le n \le N}} \quad ; \quad Y^t = (Y_1^t \quad \cdots \quad Y_N^t) = (x_{In}^t)_{\substack{1 \le j \le J \\ 1 \le n \le N}} \qquad (4)$$

In an output-based approach, the production technologyS^t is completelycharacterized by the output distance function, defined on theS^t output set as: for $1 \le t \le T$ and for the $DMU_n 1 \le n \le N$:

$$D_O^t(X_n^t, Y_n^t) = Min\left\{\theta \in]0,1]/\left(X_n^t, \frac{Y_n^t}{\theta}\right) \in S^t\right\} \qquad (5)$$

If (X_n^t, Y_n^t) belongs to the production technology set S^t then $D_O^t(X_n^t, Y_n^t) \le 1$. If $D_O^t(X_n^t, Y_n^t) = 1$ then (X_n^t, Y_n^t) is on the efficient production frontier or on the boarder of S^t and is considered as a technically efficient production unitas explained by Farrell(1957)).

The output distance measure is the reciprocal of the ratio of the greatest proportional expansion in the output quantity to make (X_n^t, Y_n^t) efficient relative to the technology S^t to the current output quantity, while attaining the current input level. Note that, the output distance measure is equal to the radial output efficiency defined by Farrel (1957).

As mentioned before, different orientations result in different efficiency measurements. The orientation choice makes difference also in distance functions which forms a basis for the radial efficiency measurements. The input distance function is defined on the S^t output set as:

$$D_I^t(X_n^t, Y_n^t) = Max\left\{\delta \in]0,1]/\left(\frac{X_n^t}{\delta}, Y_n^t\right) \in S^t\right\} \quad (6)$$

If (X_n^t, Y_n^t) belongs to the production technology set S^t then $D_O^t(X_n^t, Y_n^t) \geq 1$. As in the output distance, if $D_I^t(X_n^t, Y_n^t) = 1$ then (X_n^t, Y_n^t) is technically efficient.

Note that, under the CRS technology hypothesis, the input distance function is the reciprocal of the output distance function:

$$D_I^t(X_n^t, Y_n^t) = \frac{1}{D_O^t(X_n^t, Y_n^t)} \quad (7)$$

To calculate the Malmquist Total Factor Productivity index change, we need two single period output distance functions $D_O^t(X_n^t, Y_n^t)$ and $D_O^{t+1}(X_n^{t+1}, Y_n^{t+1})$and two mixed period output distance functions$D_O^t(X_n^{t+1}, Y_n^{t+1})$ and$D_O^{t+1}(X_n^t, Y_n^t)$:

$D_O^t(X_n^t, Y_n^t)$: The output distance function of (X_n^t, Y_n^t) relative to the reference technology S^t
$D_O^{t+1}(X_n^{t+1}, Y_n^{t+1})$: the output distance function of (X_n^{t+1}, Y_n^{t+1}) relative to the reference technology S^{+1}
$D_O^t(X_n^t, Y_n^t)$: the output distance function of (X_n^t, Y_n^t) relative to the reference technology S^t
$D_O^t(X_n^{t+1}, Y_n^{t+1})$: the output distance function of (X_n^{t+1}, Y_n^{t+1}) relative to the reference technology S^t
$D_O^{t+1}(X_n^t, Y_n^t)$: the output distance function of (X_n^t, Y_n^t) relative to the reference technology S^{t+1}

The four output distance functions can be calculated by means of the CCR (Charnes-Cooper-Rhodes)DEA model which assumes the constant return scale CRS:

$$\left(D_{O,CRS}^t(X_n^t, Y_n^t)\right)^{-1} = \underset{\eta_n,\Gamma}{Max}\,\eta_n$$
$$s.t \begin{cases} X_n^t \geq X^t.\Gamma \\ \eta_n.Y_n^t \leq Y^t.\Gamma \\ \Gamma \geq 0, \eta_n \in \mathbb{R} \end{cases} \quad (8)$$

where Γ is defined as:

$$\Gamma = \begin{pmatrix} \gamma_1 \\ \gamma_2 \\ \vdots \\ \gamma_n \\ \vdots \\ \gamma_N \end{pmatrix} \quad (9)$$

$$\left(D_{O,CRS}^{t+1}(X_n^{t+1}, Y_n^{t+1})\right)^{-1} = \underset{\eta_n,\Gamma}{Max}\,\eta_n$$
$$s.t \begin{cases} X_n^{t+1} \geq X^{t+1}.\Gamma \\ \eta_n.Y_n^{t+1} \leq Y^{t+1}.\Gamma \\ \Gamma \geq 0, \eta_n \in \mathbb{R} \end{cases} \quad (10)$$

$$\left(D_{O,CRS}^t(X_n^{t+1}, Y_n^{t+1})\right)^{-1} = \underset{\eta_n,\Gamma}{Max}\,\eta_n$$
$$s.t \begin{cases} X_n^{t+1} \geq X^t.\Gamma \\ \eta_n.Y_n^{t+1} \leq Y^t.\Gamma \\ \Gamma \geq 0, \eta_n \in \mathbb{R} \end{cases} \quad (11)$$

$$\left(D_{O,CRS}^{t+1}(X_n^t, Y_n^t)\right)^{-1} = \underset{\eta_n,\Gamma}{Max}\,\eta_n$$
$$s.t \begin{cases} X_n^t \geq X^{t+1}.\Gamma \\ \eta_n.Y_n^t \leq Y^{t+1}.\Gamma \\ \Gamma \geq 0, \eta_n \in \mathbb{R} \end{cases} \quad (12)$$

If the technology S^t is considered as the reference, the Malmquist productivity index corresponding to this reference as defined by Caves et al.(1982)is expressed by:

$$M_O^t = \frac{D_{O,CRS}^t(X_n^{t+1}, Y_n^{t+1})}{D_{O,CRS}^t(X_n^t, Y_n^t)} \quad (13)$$

Alternatively, if the technology S^{t+1} is taken as reference, then the Malmquist productivity index corresponding to this reference is defined as:

$$M_O^{t+1} = \frac{D_{O,CRS}^{t+1}(X_n^{t+1}, Y_n^{t+1})}{D_{O,CRS}^{t+1}(X_n^t, Y_n^t)} \quad (14)$$

Following the study of Färe et al. (1994), the output-based Malmquist total factor productivity index change between the date$t$ and the date $t+1$is defined as the geometric mean of these twoindices:

$$MPI_O(X_n^t, Y_n^t, X_n^{t+1}, Y_n^{t+1}) = \left(\frac{D_{O,CRS}^t(X_n^{t+1}, Y_n^{t+1})}{D_{O,CRS}^t(X_n^t, Y_n^t)} \times \frac{D_{O,CRS}^{t+1}(X_n^{t+1}, Y_n^{t+1})}{D_{O,CRS}^{t+1}(X_n^t, Y_n^t)}\right)^{1/2} \quad (15)$$

which we will note throughout the rest of the study by $TFPCh$ (Total Factor Productivity Change).

Moreover, the DEA-MPI can be decomposed under CRS assumption into two components, the first one measuring the change in the efficiency and the other measuring the change in the technology:

$$TFPCh = \frac{D_{O,CRS}^{t+1}(X_n^{t+1}, Y_n^{t+1})}{D_{O,CRS}^t(X_n^t, Y_n^t)} \times \left(\frac{D_{O,CRS}^t(X_n^{t+1}, Y_n^{t+1})}{D_{O,CRS}^{t+1}(X_n^{t+1}, Y_n^{t+1})} \times \frac{D_{O,CRS}^t(X_n^t, Y_n^t)}{D_{O,CRS}^{t+1}(X_n^t, Y_n^t)}\right)^{1/2} \quad (16)$$

The first factor on the right-hand side of the equation represents the technical efficiency change between t and $t+1$which will be noted $TEffCh$; whereas the second term, the geometric mean, stand for the technological change between t and $t+1$ which will be noted $TechCh$:

$$Technical\ Efficiency\ Change = TEffCh = \frac{D_{O,CRS}^{t+1}(X_n^{t+1}, Y_n^{t+1})}{D_{O,CRS}^t(X_n^t, Y_n^t)} \quad (17)$$

$$Technological\ Change = TechCh = \left(\frac{D_{O,CRS}^t(X_n^{t+1}, Y_n^{t+1})}{D_{O,CRS}^{t+1}(X_n^{t+1}, Y_n^{t+1})} \times \frac{D_{O,CRS}^t(X_n^t, Y_n^t)}{D_{O,CRS}^{t+1}(X_n^t, Y_n^t)}\right)^{1/2} \quad (18)$$

Thus the $TFPCh$ between$t$ and $t+1$can be expressed as:

$$TFPCh = TEffCh \times TechCh \quad (19)$$

If the value of $TFPCh$ is greater than one, it indicates a growth or improving in productivity between t and $t+1$; whereas avalue less than one means a decline or regressing productivity between t and $t+1$ and a value equal to one indicates no changein productivity from t to $t+1$.

If $TEffCh$is greater than, equal to, or less than 1 then the DMU is moving closer to, unchanging, or diverging, respectively from the production frontier. If$TechCh$is greater than, equal to, or less than 1 then the technological best practice is improving, unchanged, or deteriorating, respectively.

Assuming a variable returns to scale VRS, Färeet al.(1994) further decomposed the technical efficiency change $TEffCh$into Pure Technical Efficiency Change which we be noted $PTEffCh$ (technical efficiency under VRS assumption)and in Scale Efficiency Changes which will be note $SECh$:

$$TEffCh = PTEffCh \times SECh \quad (20)$$

This would involve the resolution of the two linear programs () and () for the output distance functions $D_{O,VRS}^t(X_n^t, Y_n^t)$ and $D_{O,VRS}^t(X_n^{t+1}, Y_n^{t+1})$by including the convexity condition$\sum_{n=1}^N \lambda_n = 1$ in the constraints equations of () and ().$PTEffCh$ is obtained by:

$$Pure\ Technical\ Efficiency\ Change = PTEffCh = \frac{D_{O,VRS}^{t+1}(X_n^{t+1}, Y_n^{t+1})}{D_{O,VRS}^t(X_n^t, Y_n^t)} \quad (21)$$

$SECh$ is obtained by the ratio of the$TEffCh$ and $PTEffCh$:

$$Scale\ Efficiency\ Change = SECh = \frac{TEffCh}{PTEffCh} = \frac{\frac{D_{O,CRS}^{t+1}(X_n^{t+1}, Y_n^{t+1})}{D_{O,CRS}^t(X_n^t, Y_n^t)}}{\frac{D_{O,VRS}^{t+1}(X_n^{t+1}, Y_n^{t+1})}{D_{O,VRS}^t(X_n^t, Y_n^t)}} \quad (22)$$

which can be expressed as:

$$SECh = \frac{D_{O,CRS}^{t+1}(X_n^{t+1}, Y_n^{t+1})}{D_{O,VRS}^{t+1}(X_n^{t+1}, Y_n^{t+1})} \Big/ \frac{D_{O,CRS}^{t}(X_n^{t}, Y_n^{t})}{D_{O,VRS}^{t}(X_n^{t}, Y_n^{t})} \quad (23)$$

Thus $TFPCh$ can be expressed as:

$$TFPCh = PTEffCh \times SECh \times TechCh \quad (24)$$

4. Empirical results

As mentioned above, the objective of this study is to assess the productivity changes of conventional and Islamic banks of 12 countries of the Middle East and North Africa region over the period 2017-2021. We have divided the banks into two classes, conventional banks including59 banks belonging to 11 countries and Islamic banks comprising 22 banks belonging to 7 countries. We have applied separately the output-oriented DEA based Malmquist Total Productivity Index for the two classes.

As aforementioned in subsection 3.1, we have selected three inputs (Total liabilities, Operating expenses including employees' expenses, depreciation and amortization and other expenses, Depreciation and amortization of tangible fixed assets) and two outputs (Operating income, Total assets except tangible fixed assets).

All the results were obtained by using the software Deap version 2.1 developed by Coelli (1996).

4.1 Empirical results of the 59 conventional banks

Table 4 below shows the geometric means of the Total Factor Productivity Change $TFPCh$ and its components $TEffCh$,$TechCh, PTEffCh$ and $SECh$ for all the 59 conventional banks during the four periods 2017-2018, 2018-2019, 2019-2020 and 2020-2021.

Table 4: Geometric means of the $TFPCh$ and its components for conventional banks per period

Year	$TEffCh$	$TechCh$	$PTEffCh$	$SECh$	$TFPCh$
2017-2018	0,983	1,015	1,003	0,980	0,997
2018-2019	0,965	1,018	0,985	0,980	0,983
2019-2020	1,032	1,000	1,001	1,031	1,032
2020-2021	1,011	0,982	1,007	1,003	0,993
Geometric mean	0,997	1,004	0,999	0,998	1,001

The results of this table are well illustrated in the two figures below:

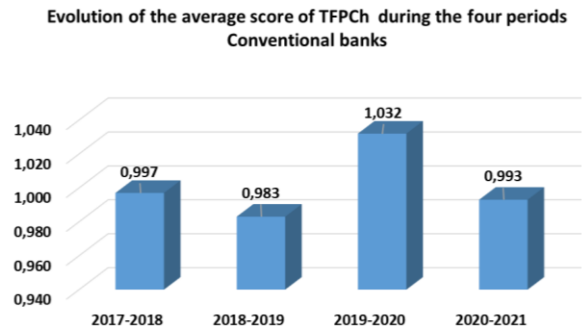

Figure 1

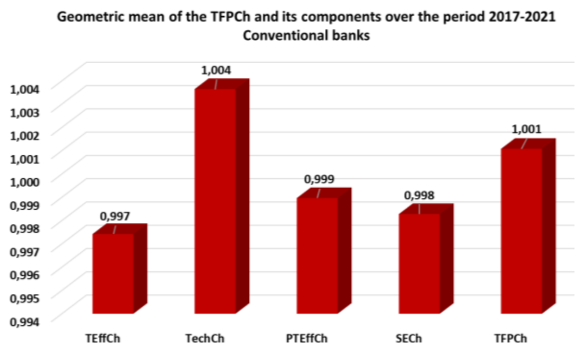

Figure 2

As shown in the table 4, the 59 conventional banks have recorded a slight progress in $TFPCh$ over the whole study period 2017-2021 with an average score of 1,001 representing an average increase of 0, 1%.

Moreover, the findings prove on the one hand that the conventional banks have registered the highest average increase of the $TFPCh$ in the period 2019-2020 with the average score of 1,032 corresponding to an average growth of 3, 2%, and on the other hand the highest regression of the $TFPCh$ in the period 2018-2019 with an average score of 0,983 presenting an average decline of 1, 7%.

According to table 4 and the figure 2, the slight progress in $TFPCh$ seems to be mainly due to the progression of the technological change$TechCh$ which exhibited a score of 1, 004, an increasing of 0,4%.

Furthermore, the conventional banks have registered a slight regression of the technical efficiency change $TEffCh$ over the whole study period 2017-2021 with an average decline of 0, 3%.

The table 5 below presents the geometric means of the Total Factor Productivity Change $TFPCh$ and its components $TEffCh$,$TechCh$, $PTEffCh$ and $SECh$ for all the 59 conventional banks over the whole study period 2017-2021.

Table 5: Geometric means of $TFPCh$ and its components of the 59 conventional banks over 2017-2021

Country	N°	$TEffCh$	$TechCh$	$PTEffCh$	$SECh$	$TFPCh$
Bahrain	1	0,990	1,024	1,000	0,990	1,013
	2	1,000	1,002	1,000	1,000	1,002
	3	0,975	1,016	0,987	0,988	0,991
Algeria	4	1,034	0,967	1,027	1,007	1,000
	5	1,002	0,957	1,003	0,998	0,959
	6	1,015	0,985	1,012	1,002	0,999
United Arab Emirates	7	0,976	1,023	0,997	0,980	0,998
	8	0,979	1,025	0,977	1,002	1,004
	9	1,029	1,092	1,008	1,021	1,123
	10	0,976	1,022	1,000	0,976	0,997
	11	1,008	1,053	1,000	1,008	1,062
	12	0,997	1,008	0,994	1,002	1,004
	13	1,000	0,941	1,000	1,000	0,941
	14	1,000	1,020	1,000	1,000	1,020
	15	0,980	1,027	0,977	1,003	1,006
Egypt	16	1,027	0,956	1,024	1,003	0,981
	17	1,023	0,984	1,011	1,012	1,007
	18	1,000	1,197	1,000	1,000	1,197
	19	1,000	0,962	1,000	1,000	0,962
Jordan	20	0,976	1,029	0,982	0,993	1,004
	21	1,008	0,970	1,007	1,001	0,978
	22	0,954	0,993	0,976	0,977	0,947
	23	1,000	0,990	0,987	1,013	0,990
	24	0,981	1,017	0,978	1,003	0,997
Kuwait	25	0,977	1,022	0,992	0,985	0,999
	26	0,986	1,019	0,994	0,992	1,005
	27	0,997	0,753	1,000	0,997	0,751
	28	0,965	1,019	0,992	0,973	0,983
	29	0,970	1,026	0,997	0,972	0,995
Lebanon	30	0,973	1,026	1,000	0,973	0,999
	31	0,977	1,029	1,000	0,977	1,005
	32	1,039	1,015	1,000	1,039	1,055
	33	0,996	1,027	1,002	0,994	1,022
Morocco	34	0,972	1,025	0,996	0,976	0,996
	35	1,000	0,991	0,991	1,009	0,991
	36	1,016	0,986	0,998	1,019	1,002
	37	1,015	0,988	0,998	1,017	1,003
	38	1,013	0,984	0,994	1,019	0,997
	39	0,988	1,008	0,999	0,989	0,996
	40	0,980	1,012	0,997	0,983	0,992
	41	1,014	0,990	0,998	1,015	1,004
	42	1,015	0,986	0,998	1,017	1,000
	43	1,000	1,057	1,000	1,000	1,057
	44	0,965	1,021	0,968	0,996	0,985
	45	1,010	0,997	1,000	1,010	1,007
	46	0,982	1,024	1,000	0,982	1,006
Oman	47	0,967	1,033	0,993	0,975	1,000
	48	0,994	1,003	1,000	0,994	0,998
	49	1,031	1,003	1,022	1,009	1,033
Qatar	50	1,000	1,026	1,000	1,000	1,026
	51	0,992	1,020	1,000	0,992	1,011
	52	1,003	1,027	0,999	1,004	1,031
Tunisia	53	0,984	1,003	0,990	0,994	0,987
	54	1,015	0,986	1,016	0,999	1,001
	55	1,026	0,992	1,025	1,001	1,018
	56	1,036	0,971	1,027	1,008	1,006
	57	1,003	1,002	1,002	1,001	1,005
	58	1,035	0,992	1,029	1,006	1,027
	59	0,988	0,969	0,980	1,008	0,958

From this table we can deduce the highest and lowest average scores of the TFPCH over the whole study period 2017-2021. This is illustrated in the table 6 below:

Table 6 Highest and lowest average scores of $TFPCh$ over the period 2017-2021 for conventional banks

	Bank	$TEffCh$	$TechCh$	$PTEffCh$	$SECh$	$TFPCh$
Max	18	1,039	1,197	1,029	1,039	1,197
Min	15	0,954	0,753	0,968	0,972	0,751

As shown on the above table, the bank n°18 (Commercial International Bank of Egypt) is the bank which has registered the highest increase in the $TFPCH$ with the average score 1,197, representing an average progression of 19,7% over the whole study period 2017-2021; which is due mainly to the technological change index $TechCh$ which has recorded the same score 1,197 with an average increase of 19,7%. The table proves that the bank n°27 (Commercial Bank of Kuwait) is the bank which has registered the highest decline in the $TFPCH$ with the average score 0,751, representing an average regression of 24,9% over the whole study period 2017-2021.

We can also deduce from the table 5above the percentage of conventional banks exhibiting average scores >1, >1 and =1 over the whole study period 2017-2021, which is illustrated I the table 7.

Table 7: Percentage of scores >1, <1 and =1 for the $TFPCh$ and for its components over 2017-2021for conventional banks

	$TEffCh$	$TechCh$	$PTEffCh$	$SECh$	$TFPCh$
Percentage of scores >1	37%	61%	24%	46%	51%
Percentage of scores <1	47%	39%	46%	42%	44%
Percentage of scores =1	15%	0%	31%	12%	5%

As shown in the table above, 51% of conventional banks has recorded scores >1 for the total factor productivity change$TFPCh$, 44% of them has exhibited scores <1 and 4% of them has recorded scores =1 over the whole study period 2017-2021.

From the table 5 above we can extract the average scores of the $TFPCh$ and its components for the conventional banks for each country over the whole study period 2017-2021 which grouped on the table 8 below.

Table 8: Average scores of the $TFPCh$ and its components per countryover 2017-2021for conventional banks

	$TEffCh$	$TechCh$	$PTEffCh$	$SECh$	$TFPCh$
Bahrain	0,988	1,014	0,996	0,993	1,002
Algeria	1,017	0,970	1,014	1,002	0,986
EAU	0,994	1,023	0,995	0,999	1,016
Egypt	1,012	1,020	1,009	1,004	1,033
Jordan	0,984	1,000	0,986	0,997	0,983
Kuwait	0,979	0,961	0,995	0,984	0,941
Lebanon	0,996	1,024	1,000	0,995	1,020
Morocco	0,998	1,005	0,995	1,002	1,003
Oman	0,997	1,013	1,005	0,993	1,010
Qatar	0,998	1,024	1,000	0,999	1,023
Tunisia	1,012	0,988	1,010	1,002	1,000

This table shows that the Banks of Egypt have registered on average the highest progress for the $TFPCh$ with the average score of 1,033 representing an average increase of 3,3%, which is maily due to an average growth of the technological change with a score of 1,020. We can alson remark that Egypt exhibits a progression for all the components of the $FTPCh$ with average scores greater than 1.

Contrariwise, the banks of Kuwait have recorded the highest decline for the $TFPCh$ with the average score of 0,941 coresponding to an average regression of 5,9%, which is mainly attributed to an average regresssion of the technological change with the average score of 0,961.

The figure 3 below presents the comparison of the average scores of the $TFPCh$for the 11 countries over the whole study period 2017-2021.

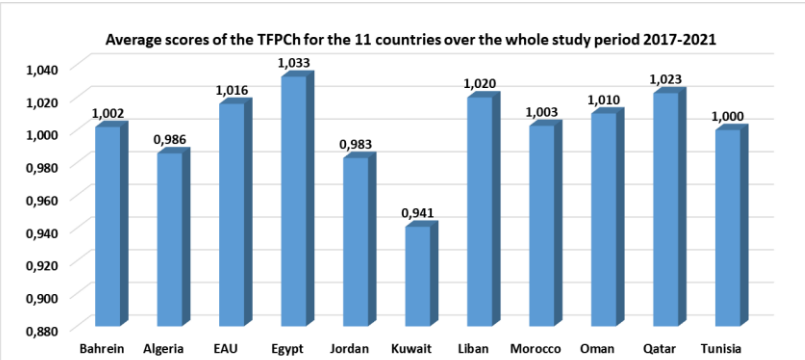

Figure 3: Comparison of the average scores of the $TFPCh$ for the 11 countries over the whole study period 2017-2021

The table 9below presents the ranking of the 11 countries according to their average scores of the $TFPCh$.

Table 9: Ranking of the 11 countries according to their average scores of the $TFPCh$

Country	$TFPCh$	Rank
Egypt	1,033	1
Qatar	1,023	2
Lebanon	1,020	3
Emirates Arabe United	1,016	4
Oman	1,010	5
Morocco	1,003	6
Bahrain	1,002	7
Tunisia	1,000	8
Algeria	0,986	9
Jordan	0,983	10
Kuwait	0,941	11

4.2 Empirical results of the 22 Islamic banks

Table 10 below shows the geometric means of the Total Factor Productivity Change $TFPCh$ and its components $TEffCh$,$TechCh, PTEffCh$ and $SECh$ for all the 22 Islamic banks during the four periods 2017-2018, 2018-2019, 2019-2020 and 2020-2021.

Table 10: Geometric means of the $TFPCh$ and its components for Islamic banks per period

Year	$TEffCh$	$TechCh$	$PTEffCh$	$SECh$	$TFPCh$
2017-2018	1,036	0,890	1,054	0,983	0,922
2018-2019	0,901	1,051	0,967	0,932	0,947
2019-2020	1,065	1,023	1,074	0,991	1,089
2020-2021	0,959	1,059	0,947	1,013	1,016
Geometric mean	0,988	1,003	1,009	0,979	0,991

The results of this table are well illustrated in the two figures below:

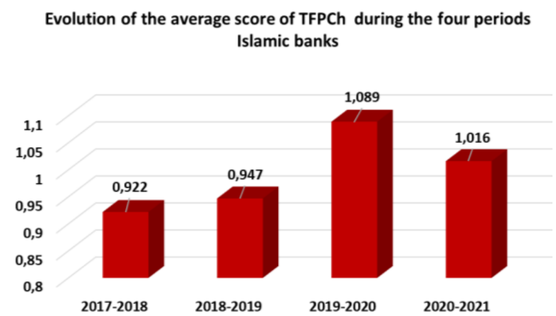

Figure 4: Evolution of the TFPCh

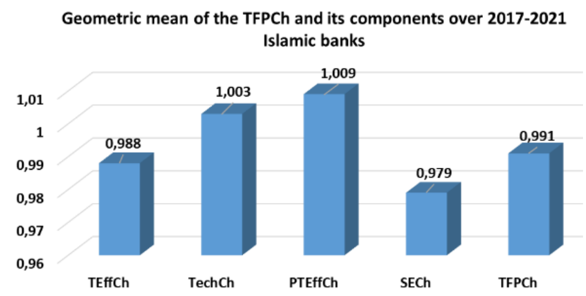

Figure 5:Geometric mean of $TFPCh$ and its components

As shown in the table 10, the 22 Islamic banks have recorded a decline in the $TFPCh$ over the whole study period 2017-2021 with an average score of 0,991 representing an average regression of 0,9%.

Moreover, the findings prove that on the one hand the Islamic banks have registered the highest average increase of the $TFPCh$ in the period 2019-2020 with an average score of 1,089 representing an average increase of 8,9%, and on the other hand the highest regression of the $TFPCh$ in the period 2017-2018 with an average decline of 1,7%.

According to table 10 and figure 5, the regression observed on the $TFPCh$ over the whole study period 2017-2021 is mainly attributed to the decline of the technical efficiency change $TEffCh$ which has exhibited a score of 0,988, corresponding to an average regression of 1,12%, due mainly to a decline in the scale efficiency change$SECh$ with an average regression of 0,979 representing an average decrease of 2,1%.

The table 11 below presents the geometric means of the Total Factor Productivity Change $TFPCh$ and its components $TEffCh$,$TechCh, PTEffCh$ and $SECh$ for all the 22Islamic banks over the whole study period 2017-2121.

Table 11: Geometric means of $TFPCh$ and its components of the 22 Islamic banks over 2017-2021

	Bank	$TEffCh$	$TechCh$	$PTEffCh$	$SECh$	$TFPCh$
Bahrain	1	1,094	1,005	1,095	1,000	1,100
	2	0,849	0,997	0,867	0,979	0,846
Saudi Arabia	3	1,025	1,027	1,029	0,996	1,053
	4	1,030	1,046	1,000	1,030	1,077
	5	0,982	1,026	0,988	0,994	1,008
	6	0,984	1,029	0,971	1,014	1,013
	7	0,905	1,012	1,005	0,900	0,916
	8	0,941	1,032	0,939	1,002	0,971
	9	0,974	1,027	0,962	1,012	1,001
	10	1,036	1,031	1,000	1,036	1,068
	11	0,995	1,027	0,980	1,015	1,022
United Arab Emirates	12	0,958	1,035	0,977	0,981	0,991
	13	0,878	1,015	0,885	0,992	0,891
	14	0,997	1,049	1,000	0,997	1,046
Morocco	15	0,730	0,872	1,000	0,730	0,637
	16	0,989	0,955	1,056	0,936	0,945
	17	1,141	0,884	1,018	1,121	1,008
Oman	18	1,239	1,105	1,232	1,006	1,369
Qatar	19	1,000	0,886	1,000	1,000	0,886
	20	1,000	1,021	1,000	1,000	1,021
Tunisia	21	1,081	1,012	1,214	0,890	1,094
	22	1,026	1,015	1,048	0,979	1,042

From this table we can deduce the highest and lowest average scores of the $TFPCH$ over the whole study period 2017-2021. This is illustrated in the table 12 below:

Table 12: Highest and lowest average scores of $TFPCh$ over the period 2017-2021 for Islamic banks

	Bank	$TEffCh$	$TechCh$	$PTEffCh$	$SECh$	$TFPCh$
Max	18	1,239	1,105	1,232	1,121	1,369
Min	15	0,730	0,872	0,867	0,730	0,637

As shown by the above table, the bank n°18 (Alizz Islamic Bank of Oman) is the bank which has registered the highest increase in the $TFPCh$ with the average score 1,369, representing an average progression of 36,9% over the whole study period 2017-2021; which can be attributed to the progression of the technical efficiency change with an average increase of 23,8% and the technological change technological change with an average increase of 10,5%. The table proves also that the bank n°15 (Al Akhdar Bank of Morocco) is the bank which has registered the highest decline in the $TFPCh$ with the average score 0,637, representing an average regression of 36,3% over the whole study period 2017-2021. The latest regression is due to the regression of both the technical efficiency change and the technological change.

We can deduct from the table 11 the percentage of Islamic banks exhibiting average scores >1, >1 and =1 over the whole study period 2017-2021 which is illustrated in the table 13 below:

Table 13: Percentage of scores >1, <1 and =1 for the $TFPCh$ and for its components over 2017-2021 for Islamic banks

	$TEffCh$	$TechCh$	$PTEffCh$	$SECh$	$TFPCh$
Percentage of scores >1	36%	77%	36%	36%	64%
Percentage of scores <1	55%	23%	36%	50%	36%
Percentage of scores =1	9%	0%	27%	14%	0%

As shown in the table above, 64% of Islamic banks has recorded scores >1 for the total factor productivity change $TFPCh$, 36% of them has exhibited scores <1 and 0% of them has recorded scores =1 over the whole study period 2017-2021.

From the table 11 we can also extract the average scores of the $TFPCh$ and its components for the Islamic banks for each country over the whole study period 2017-2021, presented in the table 14 below.

Table 14: Average scores of the $TFPCh$ and its components per country over 2017-2021 for Islamic banks

Country	$TEffCh$	$TechCh$	$PTEffCh$	$SECh$	$TFPCh$
Bahrain	0,964	1,001	0,974	0,989	0,965
Saudi Arabia	0,985	1,029	0,986	0,999	1,013
United Arab Emirates	0,943	1,033	0,953	0,990	0,974
Morocco	0,937	0,903	1,024	0,915	0,847
Oman	1,239	1,105	1,232	1,006	1,369
Qatar	1,000	0,951	1,000	1,000	0,951
Tunisia	1,053	1,013	1,128	0,933	1,068

This table shows that the Banks of Oman have registered on average the highest progress for the $TFPCh$ with the average score of **1,369** representing an average increase of 36,39%, which is maily due to an average growth of the technical efficiency change with a score of 1,239. We can alson remark that Oman exhibits a progression for all the components of the $TFPCh$ with average scores greater than 1.

Contrariwise, the banks of Morocco have recorded the highest decline for the $TFPCh$ with the average score of 0,847 coresponding to an average regression of 15,3%, which is mainly attributed to an average regresssion of the technological change and a decline on the efficiency scale.

The figure 6 below presents the comparison of the average scores of the $TFPCh$ for the 7 countries over the whole study period 2017-2021.

As shown in the table above, 64% of Islamic banks has recorded scores >1 for the total factor productivity change $TFPCh$, 36% of them has exhibited scores <1 and 0% of them has recorded scores =1 over the whole study period 2017-2021.

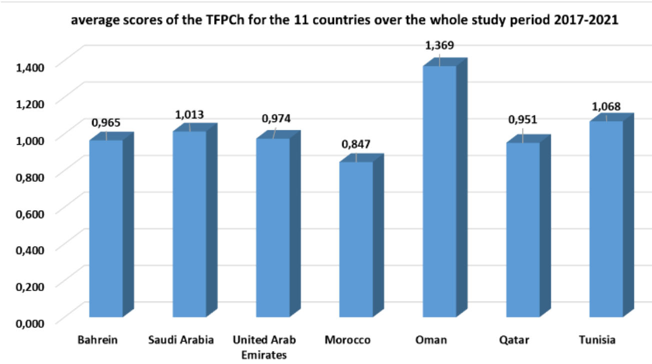

Figure 6: Comparison of the average scores of the $TFPCh$ for the 7 countries over the whole study period

It is evident that the average score of the $TFPCh$corresponding to Oman largely dominates those of the other countries.

The table 15below presents the ranking of the 7 countries according to their average scores of the $TFPCh$.

Table 15: Ranking of the 7 countries according to their average scores of the $TFPCh$

Country	$TFPCh$	Rank
Oman	1,369	1
Tunisia	1,068	2
Saudi Arabia	1,013	3
United Arab Emirates	0,974	4
Bahrain	0,965	5

Qatar	0,951	6
Morocco	0,847	7

5. Conclusion

Banks in the MENA region, as intermediary financial institutions, face great challenges of globalization and competition in the modern economy. Therefore, they are obliged to use their resources efficiently to provide quality products and services in order to operate long lastingly and survive in a high level of competitiveness conditions. They must use specific tools to measure their productivity changes over time to give confidence to bank shareholders, investors as well as to their customers.

The present study evaluated the productivity changes of the Middle East and Nort Africa (MENA) banking sector during the period2017-2021. For this purpose, Malmquist Productivity Index (MPI) based on Data Envelopment Analysis (DEA) has been employed to assess the productivity changes of conventional and Islamic banks of 12 countries of the Middle East and North Africa region over the period 2017-2021. We have divided the banks into two classes, 59 conventional banks belonging to 11 countries and 22 Islamic banks belonging to 7 countries. For the two classes, we have applied separately the output-oriented DEA based Malmquist Total Productivity Index.

As aforementioned in the study, we have selected three inputs (Total liabilities, Operating expenses including employees' expenses, depreciation and amortization and other expenses, Depreciation and amortization of tangible fixed assets) and two outputs (Operating income, Total assets except tangible fixed assets); which have been extracted from the audited balance sheets and financial statements of the banks for the study period. All the results were obtained by using the software Deap version 2.1 developed by Coelli (1996).

Regarding the conventional banks, the results show that they have recorded a slight productivity progress over the study period with an increase of 0,1%, due mainly to a technological progress with an increase of 0,4%; they have registered the highest average productivity increase in 2019-2020 with a growth of 3,2% and the highest regression in 2018-2019 with a decline of 1,7%. Over the period 2017-2021, we find that one bank of Egypt has registered the highest productivity increase with an increase of 19,7%, due mainly to technological progress, and one bank of Kuwait has registered the highest productivity decline with a regression of 24,9%. We obtain also that over the study period, 51% of conventional banks has recorded a productivity progression; the Banks of Egypt have registered on average the highest productivity progress with an increase of 3,3%, due mainly to a technological progress; the banks of Kuwait have recorded the highest productivity decline with a regression of 5,9%. Concerning the Islamic banks, the results show that over the study period, they have on average recorded a productivity decline with a regression of 0,9%; they have registered on average the highest productivity increase in the period 2019-2020 with an increase of 8,9%; the highest regression with a decline of 1,7%. We find also that over the study period one Islamic bank of Oman has registered the highest productivity increase with a progression of 36,9% and one Islamic bank of Morocco has registered the highest productivity decline with a regression of 36,3%. Other results show that 64% of Islamic banks has recorded a productivity progress over the study period and the banks of Oman have registered the highest productivity progress with an increase of 36,39%; while the banks of Morocco have recorded the highest productivity decline with a regression of 15,3%, due mainly to technological regression and efficiency scale decline.

Finally, we modestly believe that our study has generally contributed to the great literature on the measurement of the productivity change of banks between successive periods and mainly to the enrichment of rare research works that were intended for the banking industry of MENA region.

References

[1]. Aasri A. R., Lkoyaali B. (2021). Efficiency of Moroccan banks: A Data Envelopment Analysis approach. International Journal of Accounting, Finance, Auditing, Management and Economics. Volume 2, Issue 4 (July, 2021), pp.585-596. ISSN: 2658-8455.

[2]. Alexakis C., Izzeldin M., Johnes J., Pappas V. (2019). Performance and productivity in Islamic and conventional banks: Evidence from the global financial crisis. Economic Modelling. Volume 79, June 2019, Pages 1-14.

[3]. Banker R. D., Datar S. M. (1989). Sensitivity, precision, and linear aggregation of signals for performance evaluation. Journal of Accounting Research, 27(1), 21-39. Available at: https://doi.org/10.2307/2491205

[4]. Basri M.F, Amirul A.M., Nizam J.M (2018). The efficiency of Islamic banks in Malaysia: Based on DEA and Malmquist productivity index. Journal of Emerging Economies & Islamic Research 6(3) 2018, 15 – 27.
[5]. Baten A., Kasim M. M, Rahman M. (2015). Efficiency and Productivity Change of Selected Online Banks in Bangladesh: A Non-parametric Malmquist Approach. J Internet Bank Commer, 20, 121. https://doi.org/10.4172/2165-7866.1000121.
[6]. Berger A. N., Humphrey D. B. (1992). Measurement and Efficiency Issues in Commercial Banking. In Z. Griliches (ed.), Output Measurement in the Service Sectors, National Bureau of Economic Research Studies in Income and Wealth, Chicago, IL, University of Chicago Press, Vol. 56, pp. 245-279.
[7]. Casu B., Ferrari A., Zhao T. (2013). Regulatory Reform and Productivity Change in Indian Banking. The Review of Economics and Statistics, 95(3), 1066–1077.
[8]. Caves D.W., Christensen L.R., Diewert W.E. (1982). The economic theory of index numbers and the measurement of input, output, and productivity. Econometrica, 50(6), 1982, 1393-1414.
[9]. Chansarn S. (2014). Total factor productivity of commercial banks in Thailand. International Journal of Business & Society, 15(2), 215-234.
[10]. Coelli T. (1996). A computer program for stochastic frontier production and cost function estimation, Centre for Efficiency and Productivity Analysis (CEPA). (Working Paper 96/07).
[11]. Coelli T., Rao D., O'Donnell C., Battese G. (2005). An introduction to efficiency and productivity analysis. Springer (2nd), Science plus Business Media, Inc. 2005.
[12]. Cooper W., Seiford L., Tone K. (2002). Data envelopment analysis: A comprehensive text with models, applications, references and DEA-solver software. Boston: Kluwer Academic Publishers.
[13]. Dar A. H., Mathur S.K., Mishra, S. (2021). The Efficiency of Indian Banks: A DEA, Malmquist and SFA Analysis with Bad Output. Journal of Quantitative Economics volume 19, pages653–701.
[14]. Färe R., Grosskopf S., Lindgren B., Roos P. (1992). Productivity developments in Swedish Pharmacies: A non-parametric Malmquist approach. Journal of Productivity Analysis, 3, 85-101.
[15]. Fare R., Grosskopf S., Norris M., Zhang Z. (1994). Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries. American Economic Review, March 1994, 84(1), pp. 66-83.
[16]. Farrell M. J. (1957). The Measurement of Productive Efficiency. Journal of the Royal Statistical Society: Series A. Volume120, Issue3. Pages 253-281.
[17]. Garamu G. (2016). Technical efficiency and productivity of Ethiopian commercial banks: data envelopment analysis (DEA) approach. International Journal of Scientific and Research Publications, 6(9), 860-864.
[18]. Gebremedhin A. B., Liaqat A.. An Empirical Analysis of Productivity Changes in the Ethiopian Commercial Banks: Using DEA- Based Malmquist Productivity Index Approach . http://afr.sciedupress.com. Accounting and Finance Research Vol. 10, No. 1; 2021.
[19]. Irini K. (2018). Albanian Banking Sector Productivity Using Malmquist Index Research Journal of Finance and Accounting www.iiste.org. ISSN 2222-1697 (Paper) ISSN 2222-2847 (Online). Vol.9, No.12, 2018.
[20]. Isik, I., Kulali, I., Agcayazi-Y. B. (2016). Total factor productivity change in the Middle East banking. International Journal of Research in Business and Social Science (2147-4478), 5(3), 1-29. https://doi.org/10.20525/ijrbs.v5i3.296.
[21]. Jreisat, A., Hassan, H. (2016). Productivity change of the Egyptian banking sector: a two stage non-parametric approach. Topics in Middle Eastern and North African Economies, 18. J. Quant. Econ. 2021, 19, 653–701.
[22]. Jubilee R. V. W, Kamarudin F., Hafezali I. H., Razman A. L, Nurazilah Z. (2020). Analysis of Total Factor Productivity Changes in Islamic and Conventional Banks: Empirical Evidence from Three Regions. International Journal of Management and Sustainability2020 Vol. 9, No. 3, pp.161-180.
[23]. Jubilee R. V. W., Kamarudin, F., Latiff, A.R. A., Hussain H. I.,Tan, K. M. (2019). Do Islamic versus conventional banks progress or regress in productivity level? Futur. Bus. J. 2021, 7, 1–22. J. Econ, 10, 249–257
[24]. Laporšek S., Trunk A., Stubelj I. (2022). Productivity Change in European Banks in the Post-Crisis Period. Systems 2022, 10, 186. https://doi.org/10.3390/systems10050186.

[25]. Lema, T. Z. (2016). Productivity change of Ethiopian banks: a Malmquist productivity index approach: Journal of Economics and Sustainable Development, 7(21), 14-20.
[26]. Lera D. D., Rao P. H. (2016). Total factor productivity change of the Ethiopian banking sector: a Malmquist productivity index approach (MPI). PARIPEX-Indian Journal of Research, 5(1).
[27]. Mahesh HP, Rajeev M. (2007). Productivity of Indian Commercial Banks in the Pre- and Post-Liberalization Periods. The IUP Journal of Bank Management, IUP Publications, vol. 0(4), pages 17-30, November.
[28]. Malmquist S. (1953). Index numbers and indifference curves. Trabajos de Estatistica, 4-1, 1953, 209-242.
[29]. Malmquist. S. Index numbers and indifference surfaces. Trabajos de estadística, 4 (2):209–242, 1953
[30]. Maradin D., Prohaska Z., Suljic N. (2000). The Productivity of European Banking Sector: A Review of the post-2000 Literature. UTMS.
[31]. Munteanu A., Brezeanu P., Badea L. (2013). Productivity change patterns in the Romanian banking system – the impact of size and ownership on total factor productivity. Theoretical and Applied Economics Volume, 20(6).
[32]. Muvingi J., Hotera S. (2015). Zimbabwe commercials banks efficiency and productivity analysis through DEA Malmquist approach 58; 2002-2012. Data Envelopment Analysis and Decision Science, 1, 32-49. https://doi.org/10.5899/2015/dea-00090.
[33]. Otaviya S., Rani L. (2020). Productivity and its determinants in Islamic banks: evidence from Indonesia. Journal of Islamic Monetary Economics and Finance, 6(1), 189-212. https://doi.org/10.21098/jimf.v6i1.1146.
[34]. Pandey P., Singh S. (2015). Evaluating the Performance of Commercial Banks in India Using Malmquist and DEA Approach: Some Evidence. The IUP Journal of Bank Management, 14(2), 2015. 22-37.
[35]. Raphael G. (2013). A DEA-based Malmquist productivity index approach in assessing performance of commercial banks: evidence from Tanzania. European Journal of Business and Management, 5(6), 25-34.
[36]. Reshampal K., Aggarwal M. (2017). Malmquist Total Factor Productivity Index with an Illustrative Application to Indian Public Sector Banks. International Journal of Applied Business and Economic Research volume 15, Number 22 (Part 2). ISSN: 0972-7302.
[37]. Shah A.A., Wu D., Korotkov, V. (2019). Are Sustainable Banks Efficient and Productive? A Data Envelopment Analysis and the Malmquist Productivity Index Analysis. Sustainability 2019, 11, 2398.
[38]. Tadesse Z.L. (2016). Productivity Change of Ethiopian Banks: A Malmquist Productivity Index Approach. Journal of Economics and Sustainable Development. Vol.7, No.21. ISSN 2222-2855.
[39]. Thayaparan A., Pratheepan T. (1941). Evaluating total factor productivity growth of commercial banks in Sri Lanka: an application of Malmquist index. Journal of Management Research, 6(3), ISSN 1941-899X. https://doi.org/10.5296/jmr.v6i3.5513.
[40]. Törnqvist, L. (1936). The Bank of Finland's Consumption Price Index. Bank of Finland Monthly Bulletin 10, 1-8.
[41]. Varesi L. (2015). Measuring the productivity of a mainly foreign owned banking sector using non-parametric approach; Case of Albania. The 2015 WEI International Academic Conference Proceedings, Athens, Greece, 37-56.
[42]. Worthington A. (1999) Malmquist Indices of Productivity Change in Australian Financial Services. Journal of International Financial Markets, Institutions and Money 9(3):pp. 303-320. http://dx.doi.org/10.1016/S1042-4431(99)00013-X.