ISLAMIC BANKING AND FINANCE

IJIBFR VOL 9 NO 1 (2022) P-ISSN 2576-4136 E-ISSN 2576-4144

Available online at https://www.cribfb.com
Journal homepage: https://www.cribfb.com/journal/index.php/ijibfr
Published by CRIBFB, USA

EFFICIENCY OF ISLAMIC BANKS: EVIDENCE FROM ISLAMIC WINDOWS OF CONVENTIONAL BANKS IN ETHIOPIA

Abdu Seid Ali [(a)1] *Suadiq Mehammed Hailu* [(b)]

[(a)] *Head, Islamic Finance Department, Maxbridge Education and Development, Addis Ababa, Ethiopia; E-mail: abduseid81@gmail.com*
[(b)] *PhD Candidate, Çukurova University, Department of Finance, Adana, Turkey; E-mail: suadiq1434@gmail.com*

ARTICLE INFO

Article History:

Received: 28 February 2022
Accepted: 23 May 2022
Online Publication: 5 July 2022

Keywords:

Cost Efficiency
Technical Efficiency Islamic Windows
Stochastic Frontier Analysis

JEL Classification Codes:

G01, G21, G24

ABSTRACT

The study examines the cost and technical efficiency of selected Islamic banking windows of conventional banks in Ethiopia during the period of 2016-2020. The parametric method, stochastic frontier approach (SFA) was employed to measure both cost and technical efficiency of the banks. The efficiency scores of the sampled banks can be measured based on their performance in utilizing inputs to successfully generate output during the study period. It gauges the service quality of the banks taking loans and deposits as well as operating income and expenses into consideration. The study uses time series data from four conventional banks which provide Islamic banking widow in Ethiopia. The statistical findings show that the conventional banks have fairly better technical efficiency individually and collectively; however, the cost efficiency scores indicate that the banks are not efficient enough in terms of minimizing costs for a given scale and mix of outputs. Similarly, the results of the stochastic technical frontier estimates uncovers that there is positive significant relationship between the input variables namely total deposits and total operating expenses and output variables namely total financing and total operating income. The outputs remain an essential contributor to the cost efficiency in Islamic windows conventional banks in Ethiopia.

INTRODUCTION

Islamic banks have been around for more than four decades providing Shari'ah-complaint financial services in different countries. Albeit they are more ubiquitous in The Gulf Cooperation Council (GCC), Middle East and South Asian countries, the growth in other parts of the globe is slow as there are legal, regulatory, tax, skilled labor force and infrastructural challenges (Cham, 2018; Imam & Kpodar, 2016). Nowadays, Islamic financial institutions in general and banks in particular are prevalent in several parts of the world including Europe, North African and Sub-Saharan African countries. Though the share of African countries is still trivial, the prospects for imbedding Islamic banking in the region look bourgeoning given the several efforts and initiatives being embarked on to achieve that (IFSB, 2020).

Ethiopia, a country with huge unbanked population has enormous untapped potential to spur growth through financial inclusion and modernizing the financial institutions. However, there are a number of entry barriers to Ethiopian banking sector. Minimum capital requirement to establish a bank, the ascendency of state owned banks, inauspicious environment for foreign banks are some of the salient features of the sector (Kiyota et al., 2007; Fanta, 2012). As a result, it is regarded as less competitive and highly thriving as the banks merely race on overhauling their services and efficiency (together with the utilization of technological means), branch network growths, advertising and prices, put in the order of their importance (Eshete et al., 2013).

The Saga of Islamic banking in Ethiopia (legally known as interest-free banking (IFB) started in 2008 when the country's central bank, the National Bank of Ethiopia (NBE) issued a proclamation that allows the establishment of interest-free mobilization of deposit and utilization of funds. Subsequent to this proclamation, Zam Zam Bank was on the verge of commencing the first full-fledged Islamic bank in 2008 (Hailu & Bushera, 2020). Nevertheless, with an abrupt decision from the then government or central bank, the gleam of hope to set up a full-fledged Islamic bank rescinded. Following the Interest –free banking (IFB) directive, the NBE showed a green light to conventional banks to start interest-free windows

[1]*Corresponding author: ORCID ID: 0000-0001-5783-3546*

https://doi.org/10.46281/ijibfr.v9i1.1768

To cite this article: Ali, A. S., & Hailu, S. M. (2022). EFFICIENCY OF ISLAMIC BANKS: EVIDENCE FROM ISLAMIC WINDOWS OF CONVENTIONAL BANKS IN ETHIOPIA. *International Journal of Islamic Banking and Finance Research, 9*(1), 21-31. https://doi.org/10.46281/ijibfr.v9i1.1768

to cater financial services to customers who distanced themselves mainly because of religious reasons (Ahmed, 2019). The privately owned Oromia International Bank followed by the state giant Commercial Bank of Ethiopia joined the market and started providing the services (Aman, 2020). Following the footsteps of these banks, more than ten banks have commenced IFB services and several of them started IFB branches in the capital and financial hub Addis Ababa and other cities. The advent of a new political reform paves a way to reinstate the establishment of full-fledged Islamic banks (Ali et al., 2020). Zam Zam Bank, which obtained its license in September 2020 and started operation in June 2021, became the first full-fledged Islamic bank in the country while Hijra Bank became the second bank to join the banking sector.

The efficiency of banking sector has been the concern of regulators, policy makers and other stakeholders' vis-à-vis the issue of renovating their various inputs into multiple outputs in the form of financial products and services. The performance and efficiency of conventional banks in Ethiopia have been studied extensively by numerous researchers. Nevertheless, this study is the first of its kind with reference to cost and technical efficiency of Islamic banks given the absence of operational full-fledged interest-free banks and recent commencement of interest-free windows and branches under the umbrella of conventional banks. Therefore, this study aims to investigate the cost and technical efficiency of interest-free windows in selected conventional banks in Ethiopia using stochastic frontier approach (SFA) from 2016-2020. The study will fill the gap in the literature and used as a trigger to similar other studies as there are no studies focusing on interest-free windows.

The results of the study will have significant implications for academics to scrutinize the cost and technical efficiency of the remaining IFB windows and the policy makers for the germane regulations that suit the interest-free windows/branches. Furthermore, the full-fledged Islamic banks that are on the brink of joining the sector can take lessons to devise various mechanisms that make them competitive in the sector without compromising the quality of their services.

LITERATURE REVIEW

Efficiency is a multifaceted concept with diverse perspectives. From a business perspective, efficiency can be used to delineate the capability of achieving maximum yield from a possible minimum amount of input (Aguenaou, Lahrech, & Bounakaya, 2017). In this regard, banks' efficiency is defined as the minimization of cost and maximization of profit and output by employing possible best practices (McKinley & Banaian, 2005). Cost and technical efficiency are among the main types of measuring efficiency of banks.

Several studies have been undertaken using either the parametric or non-parametric efficiency measuring techniques in assessing the efficiency of conventional and Interest-Free banks. The parametric approach includes techniques such as the Stochastic Frontier Approach (SFA), Distribution Free Approach (DFA), and Thick Frontier Approach (TFA). On the other hand, non-parametric efficiency measuring techniques encompasses Free Disposable Hull (FDH) and Data Envelopment Analysis (DEA) (Adjei-Frimpong, 2013; Bhatia et al., 2018).

The Islamic banking (interest-free banking) joined the sector parallel to the conventional banking. Hence, the studies conducted to assess the banking efficiency can be categorized into three groups-studies that are conducted on the efficiency of the conventional banking, Islamic banking and comparative studies. For instance, studies like Sherman and Gold (1985); Zaim (1995); Drake and Hall (2003); Xiaogang et al. (2005); Berger (2007); Hauner and Peiris (2008); Weill (2009); Casu and Girardone (2010); Sharma and Dalip (2014) and Fernandes et al. (2018) have analyzed the efficiency of conventional banking.

Notwithstanding the aforementioned studies, authors such as; Hussein (2004); Mokhtar et al. (2008); Bader et al. (2008); Ahmad and Luo (2010); Abdul-Majid et al. (2010); Kablan and Yousfi (2011); Yahya et al. (2012); Qureshi and Shaikh (2012); Ismail et al. (2013); Johnes et al. (2014); Pradiknas and Faturohman (2015); Sillah and Harrathi (2015) ; Kamarudin et al. (2018) and Safiullah and Shamsuddin (2020) carried out a comparative studies on the efficiency of conventional and interest-free banking. A great majority of these studies found a mixed results while several of them found no change between the two bank types. Nevertheless, very few of them found that Islamic banks are more efficient than conventional counterparts and vice versa. These findings were significantly affected by countries' economic conditions, regulatory quality, political stability, technological developments etc. in general and bank size, capital structure, product standardization and innovation, managerial capability etc. in particular. Since this study at hand is destined to assess cost and technical efficiency of interest-free window banking services provided by the conventional banks in Ethiopia, pertinent researches conducted on the efficiency of full-fledged Islamic and the Interest-free window banking were reviewed in depth in the following sections.

In line with this, Hussein (2001) empirically investigated the efficiency of 17 Sudanese Islamic banks for the period between 1990 and 2000. He employed the stochastic cost-frontier approach. His finding divulged that despite differences in the efficiency of individual banks investigated, inefficiency was not a problem during the specified period of the study. Despite the fact that the overall average efficiency was unwavering for a decade, a wide-ranging gap was witnessed among Sudanese banks for the study period. Foreign banks became more efficient than state –owned and joint-ownership banks that heralds lack of institutional capacity of these banks to endure the challenge ensuing as a result of globalization.

In addition, Yudistira (2004) assessed the efficiency of 18 Islamic banks from 12 countries covering the period from 1997 to 2000 using DEA. The finding heralded that the inefficiency of sample Islamic banks was small at just around 10 percent. The author concluded that this inefficiency level is relatively low comparing to conventional banks inefficiency level. Mokhtar et al. (2006) investigated the efficiency of Malaysian conventional banks, Islamic banks, and Islamic windows by employing the Stochastic Cost-Frontier Approach during the period from 1997 to 2003. Their finding came out with two inferences. First, the efficiency level of Islamic banks showed incremental progress during the study period while

that of the conventional banks are lingered constant overtime. Second, the efficiency level of full-fledged Islamic banks was higher than the Islamic windows.

Moreover, Hassan (2006) studied the efficiency of global Islamic banks by gathering panel data from 43 Islamic banks in 21 countries in the years 1995 to 2001. To this end, he applied both parametric (the cost and profit efficiency) and non-parametric (DEA) techniques. He computed five efficiency measures of DEA namely cost, technical, scale, allocative and pure technical methods as compared to measures of performance in conventional accounting. The findings of the study reveal that Islamic banks were less efficient than the conventional banks. Furthermore, the efficiency measures are exceedingly associated with return on asset (ROA) and return on equity (ROE) signifying efficiency measures can be utilized alongside with main ratios of conventional accounting to define the performance of Islamic banks.

Furthermore, the efficiency of 16 Middle-East and Northern African (MENA) and Asian Countries' Islamic banks are analyzed by Sufian, Mohamad, and Muhamed-Zulkhibri (2008) for the period between 2001 and 2006 using Data Envelopment Analysis (DEA) technique. The results of the study showed that Islamic banks in the MENA region are more efficient in technical manner than the Asian Islamic banks. Pure technical inefficiency overshadows scale inefficiency in the Islamic banking sector in the region entailing that the Islamic banks have been organizationally inefficient in taking advantage of their resources in satisfactory manner.

Tahir and Haron (2010) conducted similar study using the data from 193 Islamic banks in Africa, Middle East, Europe, and the Far East & Central Asia using the SFA. Their study covers the time period between 2003 and 2008. Their finding shows that the efficiency of sample countries' Islamic banks has ameliorated over the study period. The finding also indicated that Islamic banks in Europe are relatively more efficient than banks in the other regions. Islamic banks in Africa are more efficient than Islamic banks in the Middle East region. Yet, Islamic banks in the Far East and Central Asia are the least efficient compared with banks operating in other regions.

Said (2012) investigated the efficiency of Islamic banks during the global financial crisis from 2007-2009 using a sample of 47 banks in different countries. He classified the sample banks based on region and size. Based on region, banks are classified into Islamic banks in Middle Eastern and non-Middle Eastern Islamic banks. Based on the size of banks considered, he categorized them into large Islamic Banks or small to medium size Islamic banks. The study covers the years 2006 to 2008 and employed the t-test and DEA. His findings posited that large Islamic banks are efficient and showed an increase in efficiency during the study period. Besides, the efficiency of small to medium Islamic banks was at a lower level. In general, the finding indicated that the efficiency of Islamic banks during the financial crisis has shown an increasing trend.

Rosman, Abd Wahab, and Zainol (2014) also assessed the efficiency of Islamic banks in the Middle Eastern and Asia during the global financial crisis. The study took place in the years 2007 to 2010. To this effect, 79 Islamic banks were chosen and their efficiency was analyzed using DEA. In general, the findings unfolded that Islamic Banks were able to maintain their operations during the financial crisis. However, most of the sample Islamic banks were inefficient in terms of scale due to operating at a reduced returns to scale. The results of the study shows that both profitability and capitalization were among the major contributing factors of the efficiency of Islamic banks. The efficiency of Islamic banks in the Middle East and North African countries was analyzed by Bahrini (2017) for the period covering from 2007 to 2012 using the Bootstrap DEA technique. The sample countries were classified into GCC and non-GCC states. The study findings indicated that Islamic banks in GCC countries were efficient during the global financial crisis and post-crisis.

More recently, Mohd Noor et al. (2020) examined the impact of bank regulation and supervision on the efficiency of 108 Islamic banks from 26 countries from 2004 to 2010 using DEA method. The findings of the study uncovers that Islamic banks in MENA and middle-income countries are more technically efficient. This is attributable to less strict regulations on capital requirement. On the contrary, substantial scale inefficiency is observed in Islamic banks in MENA and Asia and other region. Moreover, the result shows that the efficiency of Islamic banks is adversely affected by rigorous measures on capital requirement. Chowdhury and Haron (2021) studied the efficiency of Islamic banks in South East Asia using DEA and found that Islamic banks in Indonesia, Malaysia, and Brunei have enhanced their efficiencies. Parsa (2020) investigated the efficiency of Islamic and conventional banks in the GCC region and found that there is no statistically significant change between the banks. In the manner, Yusuf et.al (2021) compared the efficiency of both Islamic and conventional banks from 2014-2019 and found that there is no difference between these types of banks. Saadaoui and Khalfi (2022) assessed the efficiency of Islamic banks using Multivariate Adaptive Regression Splines and found that Islamic banks in developed countries are relatively more efficient than in developing countries.

To sum up, quite a number of studies in individual countries and in regional level reveal that there is a remarkable improvement in the efficiency of Islamic banks in the world even during the global financial crisis. This progress can be due to the enhancement in management practices of the banks, the leverage of becoming a large bank, less strict regulations on capital requirement etc. albeit there are various political, economic, institutional and regulatory measures consummated in the sampled countries. On the other hand, some studies show that Islamic banks are less efficient probably as a result of institutional weaknesses, the disadvantage of smaller bank size, regulatory challenges, lack of economies of scale, failure to cope with technological changes to mention few.

Nevertheless, it was difficult to access specific studies which merely investigate the efficiency of Interest-Free Windows. Rather, researchers such as; Mokhtar, Abdullah and Al-Habshi (2006), Kamaruddin, Safab, and Mohd (2008), Salami and Adeyemi (2017) assessed the cost and technical efficiency of both full-fledged Islamic banks and Islamic window together. Therefore, as stated above, currently, in Ethiopia conventional banks are providing Islamic banking services through window and branch systems, however; full-fledged Islamic banks are under establishment process. The fact that conventional banks have been operating for more than two decades, it seems implausible to compare interest-free windows and braches with conventional ones as the former ones

were just launched few years before. Hence, this study is aimed at measuring the cost and technical efficiency of Islamic window services of conventional banks in Ethiopia.

DATA AND METHODOLOGY

Data

Despite the fact that more than ten conventional banks started offering interest-free windows and branches, a handful of them have organized financial reports and statements that set aside both services. Hence, the study employed the sample of four banks as they have organized financial statements for the study period. Commercial Bank of Ethiopia (CBE), Cooperative Bank of Oromia (CBO), Hibret Bank (HB) and Oromia International Bank (OIB) were the banks which have organized, published and freely accessible financial statements for the IFB windows and branches. The annual financial statements were obtained from the websites of the corresponding banks. A panel data of IFB windows of the above selected conventional banks were taken and annual data were employed covering the periods from 2016-2020.

Stochastic Frontier Approach (SFA)

For the purpose of analyzing the efficiency of sampled IFB windows of the conventional banks in Ethiopia, SFA is favored and utilized. SFA has been extensively employed by previous studies while measuring efficiency of conventional banks in various countries and regions (Kaparakis et al., 1994; Kraft & Tırtıroğlu, (1998) Battese et al. (2000) Tahir et al. (2008). In the same token, numerous studies focusing on Islamic banking have also used SFA to either measure solely the efficiencies of individual Islamic banks or compare the efficiencies of conventional and Islamic banks (Mokhtar et al., 2006; Mohamad et al., 2008; Tahir & Haron, 2010; Zuhroh et al., 2015; Sadalia et al., 2018)

SFA is one of the parametric methods concurrently introduced by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977), based on the idea of approximating a stochastic cost or production frontier, which separates the estimated inefficiency into two components. SFA is preferred as it circumvents some of the problems related to deterministic frontiers by unambiguously considering the stochastic properties of the data, and differentiating in the form of a composite error term between firm-specific effects and random shocks or statistical noise (Kaparakis et al., 1994).

Cost and technical efficiency are the most broadly applied efficiency benchmark in the previous literature. Cost efficiency gauges the performance of banks corresponding to the banks with best-practice that produce the same output under the identical exogenous circumstances. The stochastic cost frontier method is based on a cost equation that relates a bank's cost to variables that incur those expenses, such as output levels and input prices.

The parametric cost efficiency is derived from a cost function. As stated by Berger and Mester (1997), the cost function can be illustrated in a natural logarithm form in this fashion:

$$In\ \mathrm{TC} = \mathrm{f}\ (In\ y_i, In\ x_i) + e_i \qquad (1)$$

Where: *In*TC denotes the natural logarithm of total costs

lnY_i is the natural logarithm of output,

InX_i is the natural logarithm of input prices;

$e_i = u_{it} - v_{it}$,

In a three-input, three-output translog setting, assume that the deterministic kernel c (yi ,wi ;β) of the multiple-output cost frontier takes the log-quadratic translog functional form, and then the stochastic cost frontier model can be written as Kumbhakar and Lovell (2003) stated:

$$In\mathrm{TC} = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln Y_i + \sum_{i=1}^{n} \beta_i \ln X_i + \tfrac{1}{2}\sum_{i=1}^{n}\sum_{i=1}^{n} \sigma_{ij} \ln Y_i \ln Y_j + \tfrac{1}{2}\sum_{i=1}^{n}\sum_{i=1}^{n} \sigma_{ij} \ln X_i \ln X_j + \sum_{i=1}^{n}\sum_{i=1}^{n} \mu \ln X_i \ln X_j + v_i + u_i \qquad (2)$$

Where: InTC is the total cost incurred by producer i

ln Y_i is a vector of output

InX_i is a vector of input

v_i is cost inefficiency component

u_i random error term

On the other hand, technical efficiency measures the capability of decision making units, such as banks or other kinds of production units to attain the maximum amount of output by a certain volume of inputs (output oriented models), or specifies the minimum required input to bring about a certain volume of the output (input oriented models). In banking studies, technical efficiency gauges bank's ability to achieve maximum output (such as loans) within a certain sets of input (such as deposits).

The production function which was first developed by Aigner, Lovell and Schmidt (1977) and Meusen and Van Den Broeck (1977) can be formulated in the following logarithm form:

$$LnY = f(x) \ln U_t - \ln V_t \quad (3)$$

Where lnY represents observed outputs

F denotes certain functional form

X is the vector of inputs

U_t is the inefficiency error term and

V_t is the random error term

The production function stated above elucidates the association between a given output variable with a certain input variables in addition to the inefficiency and random error.

The cost and technical efficiency of IFB windows of conventional banks in Ethiopia is estimated using a computer program called FRONTIER Version 4.1 which can be utilized to get maximum possibility approximations of a subsection of the stochastic frontier production and cost functions. The program was developed by Battese and Coelli (1988, 1992, and 1995) and Battese, Coelli, and Colby (1989). Besides, STATA© 17.0 software was employed to realize the estimation model.

Definition and Choice of Variables

The issue of defining and quantifying inputs and outputs for the purpose of studying the efficiency in the banking industry is a bone of contention among academics. It is crucial to scrutinize the nature of the banking sector before determining what comprises inputs and outputs of banks. Obviously, there are two key techniques contending with each other in this respect namely the intermediation and production methods (Sealey & Lindley, 1977).

The production method underscores that banks are the producers of transactions in the form of providing loans and accepting deposits to the users that is harmonized with classical economics concept of factors of production (Benston, 1965). Therefore, consistent with this method, the number of accounts or its related transactions is the preferred benchmark for output, whereas physical capital and the number of employees are considered as inputs. On the other hand, the intermediation method is based on the widely held notion that banks act as a middleman amongst various parties with the intention of smoothing financial transactions. They put themselves as a bridge between savers and depositors plummeting information asymmetries against various transaction costs transmuting savings into investments consistent with the needs and risk appetite of the investor (Scholtens & Van Wensveen, 2003)

The intermediation approach was employed by most studies which applied SFA as a tool to measure the efficiency of Islamic Banks in various countries and regions (Hassan, 2003; Mokhtar et al., 2006; Sufian, 2007; Mohamad et al., 2008; Tahir & Haron, 2010; Pramuka, 2011; Said, 2013; Sadalia et al., 2018). Since the salient edifice of conventional and Islamic banks are similar, the intermediation approach which was initially promoted by Sealey and Lindley (1977) will be employed in this study with some modifications. In line with the intermediation approach, it can be assumed that banks use deposits along with other acquired inputs to generate different classes of bank assets such as loans and investments, calculated by their monetary values.

Hence, total deposits and total operating expense are selected as inputs while total financing and total operating income are taken as outputs for the IFB windows of the conventional banks in Ethiopia. Total deposits mostly constitutes *amanah* and *wadiah* deposits in the form of current and saving accounts. The other input variable is total operating expenses which include personnel, general and administrative costs that the IFB windows incur in the process of getting profit. On the output side, total financing represents mostly *murabaha* financing which is a prominent instrument of financing in most Islamic banks in the globe. Total operating income by and large comes from *murabaha* financing activities and other commissions and service fees. Both the input and output variables are taken from financial statements of the corresponding banks from 2016-2020 and they are measured by Ethiopian Birr (Br.)

RESULTS AND DISCUSSION

The descriptive statistics of the input and output variables of the IFB windows of sampled conventional banks are shown in table 1. The mean values of total deposits heralded that the state giant, CBE surpasses other banks amassing deposits using its greatly diversified branches and dominance in the country's banking industry. In terms of financing, though CBE accumulated an enormous amount of deposit approximately 5 times more than CBO, it has provided less financing as compared to the latter.

CBO took the lead by extending higher interest-free financing than other sampled banks in the country. OIB became in the driver's seat to get the highest operating income from IFB window services followed by CBO. The ratio of TOI and TOE between the four banks show that three banks namely CBO, OIB and HB disbursed 8% -10% of their total income in the form of personnel, administrative and general expenses whereas CBE incurred about 18% to do the same which makes the former to have higher operating ratio.

Table 1. Descriptive statistics of the inputs and outputs of the banks (in Birr)

HB				
Variables	Mean	Std. Deviation	Minimum	Maximum
TD (X_1)	663,940,944	407,824,508	219,817,683	1,230,795,181
TOE (X_2)	2,065,755	3,021,978	154,574	7,412,129
TF (Y_1)	251,104,175	217,588,341	25,450,712	548,004,453
TOI (Y_2)	22,514,927	19,566,031	1,240,653	51,420,690
CBE				
Variables	Mean	Std. Deviation	Minimum	Maximum
TD (X_1)	15,112,506,980	12,583,476,310	3,171,799,839	32,516,598,420
TOE (X_2)	9,635,117	6,135,212	5,092,037	20,018,523
TF (Y_1)	903,150,030	1,362,087,340	130,760,090	3,319,502,633
TOI (Y_2)	49,626,489	62,136,522	11,721,681	160,062,342
CBO				
Variables	Mean	Std. Deviation	Minimum	Maximum
TD (X_1)	$2,837,165,520	$2,782,834,142	$80,728,801	$6,408,246,000
TOE (X_2)	$6,945,519	$6,745,614	$599	$14,725,000
TF (Y_1)	$1,307,553,400	$1,734,619,894	$1	$3,949,926,000
TOI (Y_2)	$72,093,386	$109,337,854	$288	$259,548,000
OIB				
Variables	Mean	Std. Deviation	Minimum	Maximum
TD (X_1)	1,232,678,321	1307,670,788	3,948,000	3,013,277,000
TOE (X_2)	19,039,917	5,314,470	15,000,000	28,265,341
TF (Y_1)	633,122,800	702,878,784	1,822,000	1,621,293,000
TOI (Y_2)	185,240,849	79,324,148	57,015,783	244,000,000

Source: authors' own calculation

The overall descriptive statistics of inputs and outputs of the sampled IFB windows of conventional banks are presented in table 2. Out of the mean total deposit collected from the customers of the individual banks, only 15.5% of this amount was used in the form of financing various projects. Regarding the TOI and TOE nexus, the overall mean operating ratio is almost 10% that shows an improved efficiency of the banks management at keeping costs low while engendering revenues.

Table 2. Descriptive statistics of the overall inputs and outputs of the banks

Variables	Mean	Std. Deviation	Minimum	Maximum
TD	4,961,572,942	8,496,134,681	3,948,000	32,516,598,420
TOE	9,421,577	8,098,296	599	28,265,341
TF	773,732,601	1,137,758,901	1	3,949,926,000
TOI	82,368,913	93,661,595	288	259,548,000

Source: authors' own calculation

Cost and technical efficiencies of the IFB windows of the conventional banks are illustrated in table 3. The efficiency scores of the sampled banks can be measured based on their performance in utilizing inputs to successfully generate output during the study period. It gauges the service quality of the banks taking loans and deposits as well as operating income and expenses into consideration. SFA scores run between 0(0%) and 1(100%) where the former represents technically/cost-wise inefficient banks whereas the latter signifies the efficient ones.

Table 3. Cost and technical efficiency of IFB windows of conventional banks

Banks	**Year**	**Cost efficiency**	**Technical efficiency**
CBO	2016	0.192	0.000
	2017	0.496	0.999
	2018	0.234	0.246
	2019	0.320	0.694
	2020	0.102	0.951
	Mean	**0.268**	**0.578**
OIB	2016	0.103	0.436
	2017	0.103	0.513
	2018	0.103	0.706
	2019	0.102	0.579
	2020	0.103	0.999
	Mean	**0.103**	**0.647**
HB	2016	0.105	0.399
	2017	0.157	0.600
	2018	0.122	0.805
	2019	0.140	0.999
	2020	0.102	0.613
	Mean	**0.125**	**0.683**
CBE	2016	0.121	0.073
	2017	0.299	0.105
	2018	0.101	0.041

	2019	0.117	0.055
	2020	0.196	0.198
	Mean	**0.167**	**0.094**
	Overall mean	**0.165**	**0.501**

Source: authors' own calculations

Hence, the cost efficiency figures show that CBO (26.8%) is slightly efficient than the other three banks even though the annual efficiency scores show a downward trend. CBE scores better, still low, cost efficiency scores than the remaining two banks. The overall mean cost efficiency figure of the four banks (16.5%) indicates that the banks under consideration are not able to achieve cost efficiency during the study period. This situation can be explained in various ways. The first reason can be the upshot of political unrest and public protests in different parts of the country before 2018. Subsequent to a political transition due to dissections in the ruling party, political flux and uncertainties about the fate of the country unfavorably affected the economic and financial conditions. To make matters even worse, COVID-19 has unpredictably affected the financial sector in general the banking sector in particular dwarfing resource mobilization, foreign currency mobilization, capital growth, liquidity and asset quality to mention a few (Lelissa, 2020).

However, unlike the cost efficiency figures, some banks scored far better technical efficiency scores in the course of the study period. HB (68.3%), OIB (64.7%) and CBO (57.8%) scored moderate technical efficiency scores than CBE (9.4%). Albeit the state giant, CBE amassed huge amount of deposits from IFB customers, it couldn't utilize it efficiently to finance economic activities thereby generate high operating income. The overall mean technical efficiency score (50.1%), though moderate, indicates that the sampled four banks were able to achieve better technical efficiency scores than cost efficiency.

Table 4. Stochastic cost frontier maximum likelihood parameter estimates

Variable	Parameter	Coefficient	Standard-error	t-ratio
β_0	Intercept	14.28	7.5519	-1.8908
β_1	$\ln X_1$	0.8889	0.2986	2.9763***
β_2	$\ln X_2$	0.9032	0.2227	4.0545***
Sigma-squared		8.1896	3.9897	2.0526
Gamma		0.7039	0.4950	0.2438
log likelihood function		- 48.5730		

*** Significant at 1%

Source: authors' own calculations

When we compare the mean cost and technical efficiency scores, the sampled IFB windows of conventional banks are to some extent technically efficient than cost-wise with little difference. A part from political, economic and pandemic related circumstances, low scores of cost efficiency can be delineated in different ways. Given the recent involvement of conventional banks that provide interest-free financial services in Ethiopia, start-up expenditures like advertising and promotion, personnel training and advisory costs can be huge and may adversely exert influence on their cost efficiency. Furthermore, due to low deposits in the first few years of operation, financing activities can be very insignificant and may affect the efficiency of the banks. Similar findings were documented by Kamaruddin et al. (2008) regarding the technical efficiency of Islamic windows in Malaysia.

The results of the stochastic cost frontier estimates are shown in table 4. It points out that there is positive significant relationship between the input variables (TD and TOE) and output variables (TF and TOI). A 1% change in output (TF and TOI) causes 0.88% change in TD and 0.90% in TOE. This implies that the output designated by TF and TOI remain an important contributor to the cost efficiency in IFB windows of conventional banks in Ethiopia.

Table 5. Stochastic technical frontier maximum likelihood parameter estimates

Variable	Parameter	Coefficient	Standard-error	t-ratio
β_0	Intercept	-12.4778	5.6791	-2.1971
β_1	$\ln X_1$	0.8608	0.2940	2.9275***
β_2	$\ln X_2$	0.8909	0.2165	4.1147***
Sigma-squared		7.6118	2.8942	2.6299
Gamma		0.0122	0.3390	0.0361
log likelihood function		-48.5964		

*** Significant at 1%

Source: authors' own calculations

Similarly, the results of the stochastic technical frontier estimates are illustrated in table 5. It uncovers that there is positive significant relationship between the input variables (TD and TOE) and output variables (TF and TOI). A 1% change in output (TF and TOI) causes 0.86% change in TD and 0.89% in TOE. This entails that the output symbolized by TF and TOI remain an essential contributor to the cost efficiency in IFB windows conventional banks in Ethiopia.

CONCLUSION

This study investigates the efficiency of interest-free windows of conventional banks in Ethiopia from 2016 to 2020. It measures cost and technical efficiency of the banks using stochastic frontier approach. Total financing and total operating income were selected as output variables while total deposits and total operating expenses as input variables. Moreover, stochastic cost and technical parametric estimates were used to check whether there is relationship between the variables. The statistical findings show that conventional banks which are providing interest free financial services in Ethiopia had moderate technical efficiency scores individually and collectively; however, the cost efficiency scores indicate that the banks are not efficient in terms of minimizing costs for a given scale and mix of outputs. This can be owing to internal and external reasons that sway the banking sector. Internally, the banks have embarked on providing interest-free financial services merely in recent times and there are massive start-up costs like advertising and promotion, personnel training and advisory costs that can unfavorably affect their cost efficiency. Externally, pre-2018 political unrest and widespread protests in different parts of the country and post-2018 political flux and qualms about the fate of the country critically affected the economic and financial conditions. Furthermore, the impact of COVID-19 left the banking sector vulnerable to shocks as it hampers resource mobilization, foreign currency generation, capital growth, and liquidity and asset quality.

The results from parametric estimates points out that there is positive significant relationships between the outputs and the inputs for the study period. This implies that the financing and operating income prominently contribute for the successful operations of the efficiencies of the window operations of the banks. The change in the banks' deposits and operating expenses shored up the financing and income generating activities. The new entrant full-fledged Islamic banks can take numerous lessons such as bolstering their capital size, enhancing managerial performance, cementing their capability to be competent in the sector through continues service improvement and efficient technology. The findings of this study can be used to help banks' management, policy makers, regulators and investors in the country. The banks' management can take numerous lessons to improve the efficiency and performance of the banks while policy makers and regulators can benefit from this study in order to keep the strength and reliability of the banking sector and maintaining the public confidence in the financial system. Due to the absence and inadequate organized and separate data related to Islamic banking window services, the study merely dealt with four conventional banks which are providing interest-free financial services in Ethiopia. Prospect researchers can investigate the performance and efficiency of the remaining banks employing different variables and methods with the intention of getting the whole picture about efficiency in the sector and contribute to the literature in this area.

Author Contributions: Conceptualization, A.S.A.; Data Curation, A.S.A., Methodology, A.S.A.; Validation, A.S.A. and S.M.H.; Visualization, A.S.A.; Formal Analysis, A.S.A.; Investigation, A.S.A.; Resources, A.S.A.; Writing – Original Draft, A.S.A.; Writing – Review & Editing, A.S.A.; Supervision, S.M.H.; Software, A.S.A.; Project Administration, A.S.A.. Authors have read and agreed to the published version of the manuscript.
Institutional Review Board Statement: Ethical review and approval were waived for this study, due to that the research does not deal with vulnerable groups or sensitive issues.
Funding: The authors received no direct funding for this research.
Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.
Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to restrictions.
Conflicts of Interest: The authors declare no conflict of interest.

REFERENCES

Abdul-Majid, M., Saal, D. S., & Battisti, G. (2010). Efficiency in Islamic and conventional banking: an international comparison. *Journal of Productivity Analysis*, *34*(1), 25-43. https://doi.org/10.1007/s11123-009-0165-3

Adjei-Frimpong, K. (2013). *Bank efficiency and bank competition: empirical evidence from Ghana's banking industry* (Doctoral dissertation). Available from academia.edu

Aguenaou, S., Lahrech, A., & Bounakaya, S. (2017). Analyzing banks' efficiency as a measurement of performance in the Moroccan context: Application of CAMEL Framework. *International Review of Research in Emerging Markets and the Global Economy (IRREM), 3*(1), 1105-1121.

Ahmad, W., & Luo, R.H. (2010). Comparison of banking efficiency in Europe: Islamic versus conventional banks", Kim, S.J. and Mckenzie, M.D. (Ed.) *International Banking in the New Era: Post-Crisis Challenges and Opportunities* (*International Finance Review*, *Vol. 11*), Emerald Group Publishing Limited, Bingley, pp. 361-389.

Ahmed, M. I. (2019). The progress to allow fully fledged interest free banking business in Ethiopia. *European Journal of Islamic Finance*, (14). https://doi.org/10.13135/2421-2172/4036

Aigner, D., Lovell, C. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of econometrics*, *6*(1), 21-37. https://doi.org/10.1016/0304-4076(77)90052-5

Ali, A. S., Bushera, I., & Yesuf, A. J. (2020). The potential of Islamic financial institutions in promoting small and medium enterprises (SMEs) in Ethiopia. *Journal of Economics and Political Economy*, *7*(3), 188-203. http://dx.doi.org/10.1453/jepe.v7i3.2091

Aman, A. W. (2020). Interest-free window banking and finance in Ethiopia: Inception to expansion. *Journal of Economics Library*, *6*(4), 324-337. http://dx.doi.org/10.1453/jel.v6i4.2006

Berger, A. N. (2007). International comparisons of banking efficiency. *Financial Markets, Institutions & Instruments*, *16*(3), 119-144. http://dx.doi.org/10.1111/j.1468-0416.2007. 00121

Bader, M. K. I., Mohamad, S., Ariff, M., & Shah, T. H. (2008). Cost, revenue, and profit efficiency of Islamic versus conventional banks: International evidence using data envelopment analysis. *Islamic Economic Studies*, *15*(2). http://dx.doi.org/10.1177/0972150913515579

Bahrini, R. (2017). Efficiency analysis of Islamic banks in the Middle East and North Africa region: A bootstrap DEA approach. *International Journal of Financial Studies, 5*(1), 7. https://doi.org/10.3390/ijfs5010007

Battese, G. E., & Coelli, T. J. (1988). Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data. *Journal of econometrics*, *38*(3), 387-399. https://doi.org/10.1016/0304-4076(88)90053-X

Battese, G. E., & Coelli, T. J. (1992). Frontier production functions, technical efficiency and panel data: with application to paddy farmers in India. *Journal of Productivity Analysis*, *3*(1), 153-169. https://doi.org/10.1007/BF00158774

Battese, G. E., & Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics*, *20*(2), 325-332. https://doi.org/10.1007/BF01205442

Battese, G. E., Coelli, T. J., & Colby, T. C. (1989). *Estimation of frontier production functions and the efficiencies of Indian farms using panel data from ICRISAT's village level studies* (No. 400-2016-24556).

Battese, G. E., Heshmati, A., & Hjalmarsson, L. (2000). Efficiency of labor use in the Swedish banking industry: A stochastic frontier approach. *Empirical Economics*, *25*(4), 623-640.

Benston, G. J. (1965). Branch banking and economies of scale. *The Journal of Finance*, *20*(2), 312 331. https://doi.org/10.1111/j.1540-6261.1965.tb00212.x

Berger, A. N. (2007). International comparisons of banking efficiency. *Financial Markets, Institutions & Instruments*, *16*(3), 119-144.

Berger, A. N., & Mester, L. J. (1997). Inside the black box: What explains differences in the efficiencies of financial institutions? *Journal of Banking & Finance*, *21*(7), 895-947. https://doi.org/10.1016/S0378-4266(97)00010-1

Bhatia, V., Basu, S., Mitra, S. K., & Dash, P. (2018). A review of bank efficiency and productivity. *Opsearch*, *55*(3-4), 557-600. https://doi.org/10.1007/s12597-018-0332-2

Casu, B., & Girardone, C. (2010). Integration and efficiency convergence in EU banking markets. *Omega*, *38*(5), 260-267. https://doi.org/10.1016/j.omega.2009.08.004

Cham, T. (2018). Determinants of Islamic banking growth: an empirical analysis. *International Journal of Islamic and Middle Eastern Finance and Management*, *11*(1), 18-39. https://doi.org/10.1108/IMEFM-01-2017-0023

Chowdhury, M. A. M., & Haron, R. (2021). The efficiency of Islamic Banks in the Southeast Asia (SEA) region. *Future Business Journal*, *7*(1), 1-16. https://doi.org/10.1186/s43093-021-00062-z

Drake, L., & Hall, M. J. (2003). Efficiency in Japanese banking: An empirical analysis. *Journal of Banking & Finance*, 27(5), 891-917. https://doi.org/10.1016/S0378-4266 (02)00240-6

Eshete, Z. S., Tesome, K. W., & Abebe, T. K. (2013). Competition in Ethiopian banking industry. *African Journal of Economics*, *1*(5), 176-190.

Fanta, A. B. (2012). Banking reform and SME financing in Ethiopia: Evidence from the manufacturing sector. *African Journal of Business Management*, *6*(19), 6057-6069. https://doi.org/10.5897/AJBM11.3050

Fernandes, F. D. S., Stasinakis, C., & Bardarova, V. (2018). Two-stage DEA-Truncated Regression: Application in banking efficiency and financial development. *Expert Systems with Applications*, 96, 284-301. https://doi.org/10.1016/j.eswa.2017.12.010

Hailu, S. M., & Bushera, I. (2020). Interest Free Banking in Ethiopia: Prospects and Challenges. *Uluslararası İslam Ekonomisi ve Finansı Araştırmaları Dergisi*, *6*(2), 119-137. https://doi.org/10.25272/ijisef.678972

Hassan, K. M. (2006). The X-efficiency in Islamic banks. *Islamic Economic Studies*, *13*(2), 49-78.

Hassan, M. K. (2003). Cost, profit and X-efficiency of Islamic banks in Pakistan, Iran and Sudan. *Islamic Financial Architecture*, *497*.

Hauner, D., & Peiris, S. J. (2008). Banking efficiency and competition in low income countries: the case of Uganda. *Applied Economics*, *40*(21), 2703-2720. https://doi.org/10.1080/00036840600972456

Hussein, K. (2004). Banking efficiency in Bahrain: Islamic vs Conventional banks (No. 200). The Islamic Research and Teaching Institute (IRTI).

Hussein, K. A. (2001). Operational efficiency in Islamic banking: The Sudanese experience. Islamic Research and Training Institute, Islamic Development Bank.

Imam, P., & Kpodar, K. (2016). Islamic banking: Good for growth? *Economic Modelling*, *59*, 387-401. https://doi.org/10.1016/j.econmod.2016.08.004

Islamic Financial Services Board. (2020). Islamic financial services industry stability report. *Kuala Lumpur*. Retrieved from https://www.ifsb.org/sec03.php

Ismail, F., Majid, M. S. A., & Rahim, R. A. (2013). Efficiency of Islamic and conventional banks in Malaysia, *Journal of Financial Reporting and Accounting*, 11(1), 92-107. https://doi.org/10.1108/JFRA-03-2013-0011

Johnes, J., Izzeldin, M., & Pappas, V. (2014). A comparison of performance of Islamic and conventional banks 2004–2009. *Journal of Economic Behavior & Organization*, 103, 93-107. https://doi.org/10.1016/j.jebo.2013.07.016

Kablan, S., & Yousfi, O. (2011). Efficiency of Islamic and conventional banks in countries with Islamic banking. Retrieved from https://mpra.ub.uni-muenchen.de/32951/

Kamaruddin, B. H., Safab, M. S., & Mohd, R. (2008). Assessing production efficiency of Islamic banks and conventional bank Islamic windows in Malaysia, *International Journal of Business and Management Science*, *1*(1), 31-48.

Kamarudin, F., Sufian, F., Nassir, A. M., Anwar, N. A. M., Ramli, N. A., Tan, K. M., & Hussain, H. I. (2018). Price efficiency on Islamic banks vs. conventional banks in Bahrain, UAE, Kuwait, Oman, Qatar and Saudi Arabia: impact of country governance, *International Journal of Monetary Economics and Finance*, *11*(4), 363-383. https://doi.org/10.1504/IJMEF.2018.095743

Kaparakis, E. I., Miller, S. M., & Noulas, A. G. (1994). Short-run cost inefficiency of commercial banks: A flexible stochastic frontier approach. *Journal of Money, Credit and Banking*, *26*(4), 875-893. https://doi.org/10.2307/2077953

Kiyota, K., Pietsch, B., & Stern, R. (2007). The case for financial sector liberalization in Ethiopia, IPC Working Paper Series No. 29

Kraft, E., & Tırtıroğlu, D. (1998). Bank efficiency in Croatia: A stochastic-frontier analysis. *Journal of Comparative Economics*, *26*(2), 282-300. https://doi.org/10.1006/jcec.1998.1517

Kumbhakar, S. C., & Lovell, C. K. (2003). *Stochastic Frontier Analysis*. Cambridge university press.

Lelissa, T. (2020). The Impact of COVID-19 on the Ethiopian Private Banking System. *Available at SSRN 3624944*.

McKinley, V., & Banaian, K. (2005). Central bank operational efficiency: meaning and measurement. Central Banking Publications, Available at SSRN: https://ssrn.com/abstract=2508461

Meeusen, W., & van Den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review*, 18, 435-444. https://doi: 10.12691/jbms-4-4-4.

Mohamad, S., Hassan, T., & Bader, M. K. I. (2008). Efficiency of conventional versus Islamic Banks: international evidence using the Stochastic Frontier Approach (SFA). *Journal of Islamic Economics, Banking and Finance*, 4(2), 107-130.

Mohd Noor, N. H. H., Bakri, M. H., Wan Yusof, W. Y. R., Mohd Noor, N. R. A., & Zainal, N. (2020). The impact of the bank regulation and supervision on the efficiency of Islamic Banks. *The Journal of Asian Finance, Economics, and Business*, *7*(11), 747-757.

Mokhtar, H. S. A., Abdullah, N., & Al-Habshi, S. M. (2006). Efficiency of Islamic banking in Malaysia: A stochastic frontier approach. *Journal of Economic Cooperation*, 27(2), 37-70.

Mokhtar, H.S.A., Abdullah, N., & Alhabshi, S.M. (2008). Efficiency and competition of Islamic banking in Malaysia, *Humanomics*, 24(1), 28-48. https://doi.org/10.1108/08288660810851450

Parsa, M. (2022). Efficiency and stability of Islamic vs. conventional banking models: A Meta frontier analysis. *Journal of Sustainable Finance & Investment*, *12*(3), 849-869. https://doi.org/10.1080/20430795.2020.1803665

Pradiknas, T. Y., & Faturohman, T. (2015). Efficiency of Islamic Banking Compared To Conventional Banking: Evidence From Indonesian Banking Sector. *Journal of Business and Management*, *4*(5), 540-551.

Pramuka, B. A. (2011). Assessing profit efficiency of Islamic banks in Indonesia: An intermediation approach. *Journal of Economics, Business, & Accountancy Ventura*, *14*(01), 94-106.

Qureshi, M. A., & Shaikh, M. (2012). Efficiency of Islamic and conventional banks in Pakistan: a non-parametric approach. *International Journal of Business and Management*, *7*(7), 40. http://dx.doi.org/10.5539/ijbm.v7n7p40

Rosman, R., AbdWahab, N., & Zainol, Z. (2014). Efficiency of Islamic banks during the financial crisis: An analysis of Middle Eastern and Asian countries. *Pacific-Basin Finance Journal*, 28, 76-90. https://doi.org/10.1016/j.pacfin.2013.11.001

Saâdaoui, F., & Khalfi, M. (2022). Revisiting Islamic banking efficiency using multivariate adaptive regression splines. *Annals of Operations Research*, 1-29. https://doi.org/10.1007/s10479-022-04545-2

Sadalia, I., Kautsar, M. H., Irawati, N., & Muda, I. (2018). Analysis of the efficiency performance of Sharia and conventional banks using stochastic frontier analysis. *Banks & Bank Systems*, *13*(2), 27-38. https://doi:10.21511/bbs.13 (2).2018.03

Safiullah, M., & Shamsuddin, A. (2020). Technical efficiency of Islamic and conventional banks with undesirable output: Evidence from a stochastic meta-frontier directional distance function, *Global Finance Journal*, 51, 100547. https://doi.org/10.1016/j.gfj.2020.100547

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. Available at SSRN: https://ssrn.com/abstract=2084626

Said, A. (2013). Evaluating the overall technical efficiency of Islamic banks operating in the MENA region during the financial crisis. *International Journal of Economics and Financial Issues*, *3*(2), 426-434.

Salami, O. L., & Adeyemi, A. A. (2017). Malaysian Islamic banks' efficiency: an intra-bank comparative analysis of Islamic windows and full-fledged subsidiaries. *International Journal of Business and Society*, *16*(1). https://doi.org/10.33736/ijbs.551.2015

Scholtens, B., & Van Wensveen, D. (2003). *The Theory of Financial Intermediation: An Essay on What It Does (Not) Explain* (No. 2003/1) Vienna: SUERF Studies.

Sealey Jr, C. W., & Lindley, J. T. (1977). Inputs, outputs, and a theory of production and cost at depository financial institutions. *The Journal of Finance*, *32*(4), 1251-1266. https://doi.org/10.1111/j.1540-6261.1977.tb03324.x

Sharma, S. K., & Dalip, R. (2014). Efficiency and productivity analysis of Indian banking industry using Hicks-Moorsteen approach. *International Journal of Productivity and Performance Management*, *63*(1), 57-84. https://doi.org/10.1108/IJPPM-09-2012-0096

Sherman, H. D., & Gold, F. (1985). Bank branch operating efficiency: Evaluation with data envelopment analysis. *Journal of Banking & Finance*, 9(2), 297-315. doi.org/10.1016/0378-4266 (85)90025-1

Sillah, B. M., & Harrathi, N. (2015). Bank efficiency analysis: Islamic banks versus conventional banks in the Gulf Cooperation Council Countries 2006-2012. *International Journal of Financial Research*, *6*(4), 143-150. https://doi.org/10.5430/ijfr.v6n4p143

Sufian, F. (2007). The efficiency of Islamic banking industry in Malaysia: Foreign vs domestic banks, *Humanomics*, *23*(3), 174-192.

Sufian, F., Mohamad, A. M., & Muhamed-Zulkhibri, A. M. (2008).Tahir, I. M., & Haron, S. (2010). Cost and profit efficiency of Islamic banks: international evidence using the stochastic frontier approach. *Banks & Bank Systems*, *5*(4), 78-83.

Tahir, I. M., Abu, B. N., & Haron, S. (2008). Technical efficiency of the Malaysian commercial banks: A stochastic frontier approach. *Banks & Bank Systems*, *3*(4), 65-72.

Weill, L. (2009). Convergence in banking efficiency across European countries. *Journal of International Financial Markets, Institutions and Money*, *19*(5), 818-833. https://doi.org/10.1016/j.intfin.2009.05.002

Xiaogang, C., Skully, M., & Brown, K. (2005). Banking efficiency in China: Application of DEA to pre-and post-deregulation eras: 1993–2000. *China Economic Review*, *16*(3), 229-245. https://doi: 10.1016/j.chieco.2005.02.001

Yudistira, D. (2004). Efficiency in Islamic banking: an empirical analysis of eighteen banks. *Islamic Economic Studies*, *12*(1), 2-19.

Yusuf, A. A., Santi, N., & Rismaya, E. (2021). The efficiency of Islamic banks: Empirical evidence from Indonesia. *The Journal of Asian Finance, Economics and Business*, *8*(4), 239-247. https://doi.org/10.13106/jafeb.2021.vol8.no4.0239

Yahya, M. H., Muhammad, J., & Hadi, A. R. A. (2012). A comparative study on the level of efficiency between Islamic and conventional banking systems in Malaysia. *International Journal of Islamic and Middle Eastern Finance and Management*, *5*(1), 48-62. https://doi.org/10.1108/17538391211216820

Zaim, O. (1995). The effect of financial liberalization on the efficiency of Turkish commercial banks. *Applied Financial Economics*, *5*(4), 257-264. https://doi.org/10.1080/758536876.

Zuhroh, I., Ismail, M., & Maskie, G. (2015). Cost efficiency of Islamic banks in Indonesia–a stochastic frontier analysis. *Procedia-Social and Behavioral Sciences*, 211, 1122-1131. https://doi.org/10.1016/j.sbspro.2015.11.150

Publisher's Note: CRIBFB stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.