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Article

Estimating Islamic Banks' Technical and Allocative Inefficiencies: A Shadow Cost Approach

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ABSTRACT - The main objective of the present paper is to empirically analyze the efficiency of 26 selected Islamic banks from different countries, namely: Bahrain, Jordan, Kuwait, Malaysia, Pakistan, Qatar, Saudi Arabia and UAE. The data used covers the period of 2012–2016. To measure the banks' efficiency, we used the frontier-based efficiency methodology, which was especially developed in the presence of panel data. In this respect, the panel data provided us with a fruitful framework for analyzing the efficiency. Therefore, the method employed was the shadow cost frontier based on the estimation of parametric cost inefficiency and its decomposition into both technical and allocative inefficiencies. The findings showed that the Islamic banks are cost-inefficient. With regard to the allocative inefficiency, it can be explained by excessive use of capital relative to labor, accompanied by an overuse of financial resources in terms of labor. The present study also revealed that the financial factor is overused, relative to the physical capital. Furthermore, technical inefficiency appears to be the second source of cost inefficiency as far as the Islamic banks are concerned. Overall, the findings indicate that the Islamic banks must improve their use of resources by about 43.7 percent for achieving efficiency.

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INTRODUCTION

The Islamic banking industry has emerged remarkably and developed over the last two decades. This type of banking is characterized by undertakings, eliminating the use of all forms of interest. The principle of interest prohibition has long been the cause of strong resistance to the development of modern financial tools in many parts of the Muslim world, particularly in Arab countries. It was only during the 1920s that Arab banks made their appearance in the region. The total worth of the Islamic financial services industry, which surpassed a landmark of USD 2 trillion for the first time in 2017, has further increased to USD 2.19 trillion in 2018 on the back of significant improvement across the three sectors of Islamic banking, the Islamic capital market and Islamic insurance (*Takāful*) (IFSB, 2019). Like Citibank, which established its Islamic subsidiary in Bahrain in 1982, most of the major Western financial institutions have recently been engaged in such activities in the form of subsidiaries—"Islamic windows" or financial products tailored for Muslim customers. As a symbol of Islamic financial integration with the global economy, there is even a "Dow Jones Index for the Islamic market."

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The doctrine governing banks and other financial institutions that are defined and considered to be "Islamic" can be summarized as follows: interest-based loaning (*Riba*) which is associated with usury, is forbidden by the *Qur'an*. It has been substituted by a predetermined distribution practice settled by a profit and loss sharing principle (PLS) between the investor, the bank, and the productive capital. Islamic banks' activities are based on the Islamic conception of capital and labor valuation. The lender-borrower relationship gives way to a relationship based on a more equitable sharing of risk between the lender and business proprietor or entrepreneur (Racha, 2011).

The two primary legal forms of Islamic contracts are the *Musharakah* (equity partnership investment) and *Modarabah* (profit sharing), which rely primarily on raising capital, and the consequent profits and losses of deploying it. Under the *Musharakah* contract, the bank and the customer simultaneously provide the capital necessary for the project development. The resultant benefits are distributed in proportion to each party's participation in the contract. Losses are borne equally by the bank and the customer up to their respective capital contribution. The *Mudarabah* contract pertains to a relationship of lessor-company capitals. Thus, unlike the *Musharakah* contract, project management is entirely devoted to the company. The entrepreneur's remuneration consists of a percentage of profits fixed in advance. As regards to losses, they cannot be borne by the capital lessor. Note that the entrepreneur (*Mudareb*), who initially proposes a project to be financed by the bank (*Rab al-mal*), is responsible for providing the initial capital. Today, the application of the *Mudarabah* contract can be envisaged for other economic activities.

Islamic banks have various financial instruments at their disposal, such as investments, loans, and insurance, and can also invest in other activities. As part of placement investment, Islamic financial institutions offer their customers' capital management services (*Mudareb*) while soliciting deposits (*Rab al-mal*). Fixed-term investments, such as the investment and securities accounts, are available to customers, who then have to share the participation risks with the bank. Meanwhile, neither profit nor integral return of principal is assured. Regarding the investment accounts, "registered" or "bearer" certificates are issued, entitling the holder to enjoy a share of the profits generated by activities undertaken by the investment company. Conversely, however, in the case of "sighted" accounts, the bank does not share the benefits with the depositor, but solely ensures the entire risk. A particular contract (*Murabahah*) is applied as part of projects intended for the supply of raw materials, capital goods and equipment or others. The financial institution purchases supplies at cost price and resells these to the customer at revenue cost in addition to a profit margin negotiated between the parties (Racha, 2011).

The customer can also acquire capital equipment goods or building assets through a system of leasing (*Ijara*). Specifically, the bank receives the property and puts them at the disposal of the customers, who have the opportunity to eventually become the owners, if they undertake to accomplish repayments on a savings account. Interest-free loans may also be made either in the form of a charitable loan or in the form of multiple-term account regularization. Given the fact that they have only recently been created, these banks submit any new type of transaction to the "Shariah Committee" to ensure compliance with the Islamic principles (Racha, 2011).

As part of the Islamic banks' global development and their recording exceptional growth rates in the industry, one might well wonder about the extent of their banking performance. Most customers often require that the Islamic banks' performance should at least be equal to the commercial banks. Customers no longer accept the argument that Islamic banks offer products compatible with the Shariah (Islamic law) and that therefore this justifies the fact of their being more expensive. Moreover, competition stemming from the Islamic windows established by conventional banks is provoking Islamic banks to take drastic measures to improve their performance, e.g., by recruiting personnel with the best competencies and qualifications.

Defining and measuring performance is crucial. Indeed, the means through which companies measure performance is critical to their survival and progress, as it plays a vital role in the development of strategic plans, in the assessment of organizational objectives, and in compensating managers. In this respect, the question that might be asked is: Do Islamic banks enjoy a sufficient level of performance, enabling them to ensure their sustainability?

According to theoretical studies performed regarding the case of conventional banks, one may well notice that "banking performance" is represented by some quantitative parameters such as financial indicators (ROA, ROE, etc.). Although the latter reflect conventional banking performance, we believe they are incomplete, and therefore insufficient in the Islamic banks' case. Still, these approaches have been criticized by several researchers: for instance, Cummins and Weiss (2000) for the example of insurance and Berger and Humphrey (1997) in the case of banking, among many others. Cummins et al. (1999) have proposed adopting a more general approach; namely, the frontier approach.

The rest of the paper is organized as follows. The studies sheds light on some selected literature dealing with efficiency in the Islamic banks. Next, details the methodology employed in the study and develops the econometric model to be used for the estimation and the decomposition of cost inefficiency and describes the data sources and empirical results. Finally, we present the summary and conclusion.

LITERATURE REVIEW

In this section, we shed light on some studies dealing with the efficiency of Islamic banks. There are various studies in the literature focusing on the issue of the efficiency of Islamic banking. We could note several empirical investigations carried out to examine the efficiency of Islamic banks.

Studies on GCC Islamic Banks

Bahrini (2011) has analyzed the technical efficiency of Islamic banks in the Middle East and North Africa (MENA) region during the period of 2007–2012. He utilized the data envelope approach (DEA) in this context to decompose the obtained overall technical efficiency scores into pure technical efficiency and scale efficiency scores. His results showed that pure technical inefficiency was the main source of overall technical inefficiency, rather than scale inefficiency. These findings were confirmed for all MENA Islamic banks. Similar results were also found for the two subsamples: Gulf Cooperation Council (GCC) and non-GCC Islamic banks.

Rahman and Rosman (2013) examined the efficiency of selected Islamic banks in MENA countries (including GCC) and Asian countries during the period of 2006–2009. The findings indicated that the main source of technical inefficiency was the scale of their operations. On average, Islamic banks from Asian countries were found to be relatively more efficient than those in MENA countries. Remarkably, most of the efficient Islamic banks were from the GCC. The differences in scores for the Islamic banks in the MENA countries and Asian countries might be due to the country-specific factor that influences the efficiency score. It is interesting to note that the economic condition of a country was found to be the main contributing factor of the bank's efficiency.

Moualhi (2015) evaluated the efficiency of 33 Islamic banks operating in the MENA region during the years of 2006–2012, using the DEA approach. The findings suggested that pure technical inefficiency dominates scale inefficiency in the Islamic banking sector, which can be attributed to their relative inability to monitor operating costs and optimum use of resources. Furthermore, the largest Islamic banks tend to operate at a constant return to scale or decreased return to scale, whereas the smallest Islamic banks tend to operate at constant return to scale or at increased return to scale.

Bahrini (2016) examined the technical efficiencies of the 33 Islamic banks in MENA region during and after the global financial crisis by using DEA and bootstrap DEA. He found that the technical inefficiencies of the Islamic banks were mainly attributable to pure technical inefficiencies rather than scale inefficiencies. His results showed that over the period of the study the technical inefficiency of MENA Islamic banks was mainly explained by pure technical inefficiency rather than scale inefficiency.

Studies Comparing Islamic and Conventional Banks

Majeed and Zanib (2016) analyzed the efficiency of both Islamic and conventional banks in Pakistan during the years of 2007–2014. The efficiency was estimated for three types of banks by employing DEA. The findings suggested that conventional banks are more efficient in terms of total technical efficiency and pure technical efficiency than Islamic banks. They also indicated that Islamic banks are managerially inefficient due to the misallocation of resources. Moreover, the findings revealed that scale inefficiency is lowest for Islamic branches of conventional banks.

Sadiq et al. (2017) measured the real cost efficiency of Islamic banks operating in Pakistan during the period of 2003–2015, using the panel stochastic approach. Their results revealed that the Islamic banks in Pakistan are 64 percent inefficient in the cost minimization process. This high level of inefficiency represents the challenge that Islamic banks in Pakistan face in coping with the changes in institutional and regulatory requirements.

More recently, Samad (2019) investigated the efficiency of the Islamic banks of Bangladesh during the years of 2008–2015. The DEA was employed and the findings indicated that the pure technical efficiency of the Islamic banks of Bangladesh dominated the technical efficiency. The results also showed that the efficiency of Islamic banks was positively correlated to capital adequacy and the number of bank branches, and negatively correlated with poor loan quality, higher liquidity claims, and bank size.

Some of these studies, most of which are based on a comparison between the efficiency of Islamic and conventional banks, such as Samad (2004), Bashir and Hassan (2004), Beck et al. (2013), and Srairi (2010, 2013), have witnessed a significant breakthrough. These studies assess the efficiency of Islamic banks using financial ratios. Gishkori and Ullah (2013) studied the efficiency of 34 Islamic, traditional, and foreign banks in Pakistan using DEA methodology to measure technical and allocative efficiency during the period from 2007 to 2011. Their results exhibit the low technical efficiency of Islamic banks compared to that of conventional banks. Ahmed (2010) studied the performance of Islamic and conventional banks in the GCC region by using financial ratios, for the period of 2006–2009. The results show superiority in terms of performance among Islamic banks compared to conventional banks. Kamaruddin et al. (2008) evaluated the efficiency of Islamic banks operating in Malaysia, using DEA. The results showed that Islamic banks are relatively better able to control their costs. Mohamad Noor and Ahmad (2012) showed the high efficiency level of Islamic banks when applying the non-parametric DEA method to a sample comprising 78 Islamic banks belonging to 25 countries, for the period of 1997–2009. Their study also showed the correlation between the efficiency of the bank and loan intensity, size, capitalization, and profitability. Besides, Islamic banks seem to be more efficient in middle-income countries, while they are less efficient in low-and high-income countries, which is not consistent with the study of Ahmad et al. (2010), who conducted an assessment of the efficiency of Islamic banks in 25 countries during the period 2003–2009, using DEA.

The latter study showed that banks in high-income countries are more efficient than banks in low-income countries, which supported the research of Al-Khasawneh et al. (2012) showing that Islamic banks achieve higher efficiency in average revenues compared to traditional banks in North Africa. Brown and Skully (2003) examined the efficiency of Islamic banks in several countries using both DEA and financial ratios and found that Islamic banks in Iran were the most efficient among them, while the Sudanese Islamic banks ranked last. The study of Qureshi and Shaikh (2012) emphasizes the need to encourage Islamic banks to reach efficiency limits, and unlike those that show the relative efficiency of Islamic banks over conventional banks, there are also several studies that demonstrate the inefficiency among Islamic banks compared to conventional banks. Johnes et al. (2009) pointed out that the level of efficiency varies according to the method of estimation. According to the analysis of financial ratios, Islamic banks are more efficient in terms of profit than conventional banks in the GCC countries for the period of 2004–2007, while the result was the opposite when using the data envelope method, although previous research shows that there is no study that focused on Arab countries only, and that the study is compared to those in other countries that have experience in managing Islamic banks such as Iran, Turkey, and Malaysia, which makes it an unfair comparison for Islamic banks in the Arab countries. This study differs from previous ones as it tests efficiency among Islamic banks per se, rather than comparing Islamic banks and traditional banks, to determine the extent to which these banks are able to attract attention to overcome the obstacles they face to promote them and support their role in the economic development.

Wahid (2016) examined whether Malaysian Islamic banks were more efficient relative to conventional banks over the period of 2004–2013. Also, the study investigated the determinants of efficiency for both Islamic and conventional banks in Malaysia during the period of observation. A panel data regression analysis was carried out to examine the determinants of efficiency for both types of banks. Although the non-parametric test indicated that technical efficiency of conventional banks was different and higher than that of Islamic banks, the regression analysis based on size of banks suggested that this was only true for small banks. In fact, for the sample of large banks, the result revealed that Islamic banks were technically more efficient than conventional banks.

Studies Using Panel Stochastic Frontier Approach

Sadiq et al. (2017) measured and compared the real cost efficiency of full-fledged Islamic banks operating in Pakistan between the years of 2003 to 2015, using the panel stochastic frontier approach (SFA). The results surprisingly revealed that the Islamic banks in Pakistan were only 36 percent cost efficient, which can be attributed to the challenges they face because of parallel Islamic and conventional banking systems and the nature of support from the regulatory and economic system. When determining the factors of efficiency for banking, fixed effect estimates revealed that operating efficiency and asset utilization had a positive effect while profit margin had a negative effect on cost efficiency. The authors concluded that Islamic banks were facing issues of excess liquidity, inadequate support from regulatory authorities and competition from the conventional banking system, which were causing inefficiency in cost management.

Studies using Bootstrap DEA Method

More recently, Samad and Chowdhury (2019) applied the Bootstrap DEA method to measure the technical efficiencies of the Islamic banks of Bahrain and the United Arab Emirates (UEA) using panel data of 2011–2016. They found that 95 percent confidence interval mean bias-corrected overall technical efficiencies of the Islamic banks of Bahrain were less than those of UAE Islamic banks. This suggested that the average inefficiency of the Islamic banks of Bahrain was higher than that of the UAE banks and the difference was significant.

Samad (2019) investigated the technical, pure, and scale efficiencies of the Islamic banks of Bangladesh during 2008–2012. He applied DEA and found that the efficiency of Islamic banks was positively related to their capital adequacy and the number of branches and negatively related to poor loan quality, higher liquidity claims and bank size.

We can conclude from reviewing the literature that there are more studies on the technical efficiencies of the Islamic banks, which have used DEA than other approaches. As far as we know, there is no paper dealing with the estimation of cost frontier-based efficiency for Islamic banks. Moreover, to our knowledge, none have examined the efficiency of Islamic banks by using price shadow approach. The present study is the first of its kind as regards to the empirical analysis of Islamic banks' cost efficiency. Therefore, the present paper is an important contribution to the Islamic banking efficiency literature.

METHODOLOGY

Efficiency is a concept used to describe the production set highlighting the input-output combination. As the set of production possibilities is a priori unknown, it has to be estimated from data on firms' inputs and outputs belonging to this set. Two major approaches are frequently used to construct the envelope of the game of production possibilities, and from there estimate productive efficiency. On the one hand there is the non-parametric approach or the linear programming approach, while on the other hand we have the econometric or parametric approach (Hamdani et al., 2014).

The two approaches, data envelopment analysis (DEA) and stochastic frontier analysis (SFA), are apparently estimating the same underlying efficiency values, but the nature of the two methods is very different. In general, the parametric approaches have greater difficulty in distinguishing between technical and allocative efficiencies than DEA. A few models have been developed based on shadow prices, which have the possibility of distinguishing between technical and allocative efficiency. The shadow cost frontier employed in this paper is the most important among these models. In our knowledge, it is the first time that this model is being applied to estimate efficiency based on a panel data set of Islamic banks.

We use the new frontier-based efficiency methodologies to measure banks' efficiency, especially those developed in the presence of panel data. In this respect, Greene (2003) states that the panel data provide a fruitful framework for analyzing efficiency and developing new techniques. Then, one can estimate technical efficiency, cost efficiency, profit efficiency, and revenue efficiency. In what follows, we limit ourselves to the case of the parametric cost frontiers.

Cost Frontier and Cost-Efficiency

There is an extensive literature that pertains to the cost theory, primarily based on the works of Varian (1984) and Chambers (1998), among many others.

Kumbhakar & Lovell (2000) define a cost frontier following the relationship:

$$C(y, p) = \min_{x} \{p'x, x \in L(y)\}$$

with

$L(y)$ being called an input bundle (Coelli et al., 1999) or the input set of production technology (Kumbhakar & Lovell, 2000).

$p' = (p_1,..., p_N) \in \Re_+^N$ is a vector of input prices, x

$x' = (x_1,..., x_N) \in \Re_+^N$ is a vector of inputs used to produce an output vector $y' = (y_1,..., y_M) \in \Re_+^M$.

The function $C(y, p)$ enables achieving the minimum cost necessary to produce an output vector y, given the inputs' prices and production technology.

The cost efficiency provides an idea about the situation in terms of cost in respect of the most efficient banks in the sample that produce equivalent output and operate under similar conditions. This type of efficiency is directly obtained by estimating a cost frontier. If we construct a cost frontier for any bank, the gap between current production costs and production costs estimated on the frontier represents the cost inefficiency. Cost efficiency encompasses technical efficiency and allocative efficiency. A bank is considered inefficient in terms of cost if it uses the wrong proportion of inputs, given the input price (allocative inefficiency), or if it underutilizes its inputs (technical inefficiency), or both simultaneously. Measurement of cost efficiency is a function, such that $CE(y, x, p) = C(y, p) / p'x$. This measure reports the minimum cost to the observed cost (Kumbhakar & Lovell, 2000).

Estimation and Decomposition of Cost-Efficiency: A Shadow Price Approach

Atkinson and Cornwell (1994) proposed a parametric measurement of technical and allocative inefficiencies based on a dual cost function. The authors adopted the shadow cost approach to decompose the overall cost efficiency into technical and allocative efficiencies. In the parametric approach, allocative inefficiency is measured by assuming that the firm minimizes a shadow (behavioral) cost system. In this respect, several decomposition types have been advanced in the literature, among which are the original works developed by Atkinson and Cornwell (1994), Atkinson and Primont (1994), Kumbhakar (1997), Atkinson and Primont (2002), to cite a few. Based on this literature, Chaffai (1998) proposed a methodology enabling the decomposition of the cost efficiency into technical and allocative efficiencies. This is the methodology that we adopted and applied in the case of the Islamic banking industry.

Decomposing the Cost-Inefficiency

The estimation of a stochastic shadow cost function, expressed in terms of shadow input prices and outputs, was addressed for the first time by Atkinson and Cornwell (1994). Chaffai (1998) proposed decomposing cost efficiency without imposing any restrictions, while offering a method to estimate the firm-specific and time-variant allocative inefficiency. Regarding our case, we retained the same methodology to estimate and decompose the Islamic cost inefficiency. Thus, the cost frontier proposed is as follows:

$$\begin{aligned} Lnc_{it} &= \gamma_0 + \sum_{j=1}^{M} \gamma_j Lny_{jit} + \sum_{j'=1}^{N} \alpha_{j'} Lnp_{j'it} \\ &+ 0.5 \sum_{j=1}^{M} \sum_{j'=1}^{M} \gamma_{jj'} Lny_{jit} Lny_{j'it} \\ &+ 0.5 \sum_{j=1}^{N} \sum_{j'=1}^{N} \delta_{jj'} Lnp_{jit} Lnp_{j'it} \\ &+ \sum_{j=1}^{M} \sum_{j'=1}^{N} \beta_{jj'} Lny_{jit} Lnp_{j'it} + u_{it} + v_{it} \end{aligned} \qquad (1)$$

The composite error is an additive error-term with an asymmetric component representing inefficiency $(u_{it} \geq 0)$, and a usual (or symmetric) part, v_{it} , with zero mean.

The problem consists in recognizing how to decompose cost efficiency, especially when adopting a flexible, functional form (e.g., Translog, CES, Fourier, etc.) for production technology.

Modeling Allocative Inefficiency

A firm is supposed to optimize its costs by adopting an input price system that is not determined by the market, called shadow prices (Chaffai, 1998). Lau & Yotopolous (1971) and Atkinson & Halvorsen (1984) approximated the shadow prices according to the following price vector:

$$p^* = [p_1^*, \ldots, p_N^*] = [k_1 p_1, \ldots, k_N p_N], \ k_j \succ 0 \ \ \forall j = 1, \ldots, N \qquad (2)$$

The parameters k_n (n=1,..., N) measure the divergence of the actual and the shadow prices for a given firm.

Given the price system, to be determined afterwards, the shadow cost function can be represented by the model below:

$$C^* = \sum_n p_n^* x_n = \sum_n p_n h_n(y, p^*) = C(y, p^*) \qquad (3)$$

Differentiating the shadow cost function concerning the shadow prices for *i*-th input gives the expression below:

$$S_{it} = \frac{\partial Lnc^*}{\partial Lnp^*} = \frac{\partial Lnc^*}{\partial Lnk_i p_i} = \frac{\partial c^*}{\partial k_i p_i} * \frac{k_i p_i}{c^*}, \quad i = 1,\ldots,N \tag{4}$$

However, regarding the Shephard's Lemma, we can write:

$$\frac{\partial c^{\bullet}}{\partial k_i p_i} = \frac{\partial c^{\bullet}}{\partial p_i^{\bullet}} = x_i \tag{5}$$

Which implies that $\frac{\partial Lnc*}{\partial Lnp*} = x_i * \frac{k_i p_i}{c*} = M_i^*$, leading to $x_i = M_i^* * c^* * (k_i p_i)^{-1}, \forall i = 1,\ldots,N$

The actual cost function is equal to:

$$C^* = \sum_i p_i x_i = \sum_i p_i M_i^* c^* * (k_i p_i)^{-1} \tag{6}$$
$$= c^* * \sum_i M_i^* * (k_i)^{-1}, \quad \forall\, i = 1,\ldots,N$$

The logarithmic expression of the actual cost function turns out to be:

$$LnC^A = Lnc^* + Ln\sum_n M_i^* * (K_i)^{-1} \tag{7}$$

For the *i*-th input observed, the share equations are given by:

$$M_i^A = \frac{x_i p_i}{C^A} = \frac{M_i^* C^* (k_i p_i)^{-1} p_i}{C^* \sum_i M_i^* * (k_i)^{-1}} \tag{8}$$
$$= \frac{M_i^* (k_i)^{-1}}{\sum_i M_i^* * (k_i)^{-1}}$$

To correspond to a well-behaved production structure, the cost function has to check the regularity conditions; continuity, symmetry, linear homogeneity of degree 1 in input prices, monotonicity in prices and outputs, and concavity in prices.

Continuity

The cost function continuity in respect of input prices and outputs implies that the function is non-negative for any non-negative output. Since cost-related data, i.e., factor prices and outputs, are most often observed, this condition is, then, usually satisfied (Kumbhakar & Lovell, 2000).

Symmetry

The symmetry constraints are:

$\gamma_{jj'} = \gamma_{j'j}$ and $\delta_{jj'} = \delta_{j'j}$

Monotonicity

The translog cost function is considered to be monotonic in outputs if marginal costs $\left(\frac{\partial C}{\partial y} \geq 0\right)$ are positive.

Linear Homogeneity of Degree 1 in Input Prices

This constraint requires that $\sum_{j'=1}^{N} \alpha_{j'} = 1$. This condition is satisfied whenever we normalize all input prices and the cost by a given price (In our case, we normalize all input prices $p_{j'it}$ and cost by p_{1it}).

Concavity

According to the economic theory, any cost function must be concave in respect of the input prices. This stems from the fact that if an input price increases, the increase in total costs should be proportional because of substitution among production factors. In this regard, a sufficient condition for the overall concavity is that the Hessian matrix of C(p, y) must be semi-definite negative.

Knowing that $\sum_{i} M^*_{jit} = 1$ and $k_{1i} = 1$, the shadow cost function can be written as:

$$
\begin{aligned}
Ln(c_{it} / p_{1it}) = \gamma_0 + \sum_{j=1}^{M} \gamma_j Lny_{jit} + \sum_{j'=2}^{N} \alpha_{j'} Ln(p_{j'it} / p_{1it}) \\
+ 0.5 \sum_{j=1}^{M} \sum_{j'=1}^{M} \gamma_{jj'} Lny_{jit} Lny_{j'it} \\
+ 0.5 \sum_{j=2}^{N} \sum_{j'=2}^{N} \delta_{jj'} Ln(p_{jit} / p_{1it}) Ln(p_{j'it} / p_{1it}) \\
+ \sum_{j=1}^{M} \sum_{j'=2}^{N} \beta_{jj'} Lny_{jit} Ln(p_{j'it} / p_{1it}) + A_{it} + T_{it} + v_{it}
\end{aligned}
\tag{9}
$$

with,

$$
\begin{aligned}
A_{it} = \sum_{j'=2}^{N} \alpha_{j'} Lnk_{ji}(t) + 0.5 \sum_{j=2}^{N} \sum_{j'=2}^{N} \delta_{jj'} Lnk_{ji}(t) Lnk_{j'i}(t) \\
+ \sum_{j=2}^{M} \sum_{j'=2}^{N} \gamma_{jj'} Lnk_{ji} Ln(p_{j'it} / p_{1it}) \\
+ \sum_{j=1}^{M} \sum_{j'=2}^{N} \eta_{yjj'} Lny_{jit} Lnk_{ji}(t) + Ln\left\{1 - \sum_{j} M_{jit}\left(1 - k_{ji}^{-1}(t)\right)\right\}
\end{aligned}
\tag{10}
$$

The share equations become:

$$
\begin{aligned}
M_{jit} = \frac{x_{jit} p_{jit}}{C_{it}} = \frac{M^*_{jit} C^*_{it} (k_{ji} p_{jit})^{-1} p_{jit}}{C_{it}} \\
= \frac{C^*_{it}}{C_{it}} M^*_{jit} (k_{ji})^{-1} = \frac{M^*_{jit} (k_{ji})^{-1}}{1 - \sum_{j} M^*_{jit} \left(1 - (k_{ji})^{-1}\right)}
\end{aligned}
\tag{11}
$$

The allocative inefficiency parameter can be specified in such a way as to reflect the individual and temporal dimension. Indeed, we can propose a specification that helps check this condition; namely, the functional form proposed by Chaffai (1998). In this case, the allocative inefficiency parameter can be expressed as follows:

$$k_{ji}(t) = k_{ji}\exp\{b_j * t\} \tag{12}$$

Similarly, to account for individual and temporal variability of technical inefficiency, one can use the functional forms advanced in the literature, e.g., those by Cornwell et al. (1990), Battese and Coelli (1995), etc.
Analytically, the technical inefficiency can be written as:

$$T_{it} = \theta_{0i} + \theta_{1i}t + \theta_{2i}t^2 \tag{13}$$

However, Chaffai (1998) suggests estimating technical and allocative inefficiencies by adopting the two-step method. Indeed, his method consists of the following steps:

Step 1:
Estimate the equation system consisting of the shadow cost frontier and the shadow share equations using the seemingly unrelated regression (SUR) method. Residuals of the cost frontier provide an estimate of the following error term $T_{it} + v_{it}$.

Step 2:
The residuals recovered in the first step are regressed on the trend and its square in conformity with the specification of Cornwell et al. (1990). In this case, the technical efficiency can be given by the expression:

$$\begin{aligned} TE &= \exp\left(-\hat{T}_{it}\right) \\ &= \exp\left\{\min\left(\hat{\theta}_{0i} + \hat{\theta}_{1i}t + \hat{\theta}_{2i}t^2\right) - \left(\hat{\theta}_{0i} + \hat{\theta}_{1i}t + \hat{\theta}_{2i}t^2\right)\right\} \end{aligned} \tag{14}$$

Subsequently, Chaffai proposes estimating the allocative efficiency by the expression:

$$AE = \exp\left(-\hat{A}_{it}\right) \tag{15}$$

However, there is no guarantee that the estimated term $\hat{A}_{it}$ is positive, since it depends on the data and the estimated parameters (see Equation 10 above). To overcome this shortcoming, we propose to replace $\hat{A}_{it}$ with $\hat{A}_{it}^2$. Then Equation 15 becomes:

$$AE = \exp\left(-\hat{A}_{it}^2\right) \tag{16}$$

In this way, we are sure that the estimated allocative inefficiency scores will lie between 0 and 1.
Finally, an estimate of the overall cost efficiency is obtained via:

$$CE = \exp\left(-\left\{\hat{T}_{it} + \hat{A}_{it}^2\right\}\right) = TE * AE \tag{17}$$

RESULTS
It is worth recalling that to construct a cost frontier via a parametric methodology, we must have a reliable database concerning the various outputs produced by Islamic banks, the production factors' prices (capital and labor), as well as the different costs incurred by these banks.

Data and Variables

The primary data source is Bank Scope and the annual reports of Islamic banks available on the internet. The available data deal with 26 Islamic banks distributed as follows: Bahrain, Jordan, Kuwait, Malaysia, Pakistan, Qatar, Saudi Arabia and UAE, and observed over five years (2012–2016). All variables are converted into US Dollars using end-of-year market value and deflated by CPI. As shown in Table 1, the sample consists of 26 Islamic banks.

Table 1: The Sample Size

Country	Bank Name
UAE	Abu Dhabi Islamic Bank Dubai Islamic Bank Sharjah Islamic Bank Emirates Islamic Bank
Kuwait	Boubyan Bank Kuwait Finance House
Saudi Arabia	Bank AlJazira Al Rajhi Bank
Bahrain	ABC Islamic Bank Bahrein Islamic Bank Al Baraka Islamic Bank Capivest Investors Bank Kuwait Finance House Bahrain liquidity Management Center
Qatar	First Finance Company Qatar International Islamic Bank
Jordan	Islamic International Arab Bank Jordan Islamic Bank
Malaysia	Bank Islam Malaysia Bank Muamalat Bank Rakyat CIMB Islamic Bank
Pakistan	Albaraka Pakistan Faisal Bank Meezan Bank Limited

Variables Specification

According to several studies (e.g., Assaf et al., 2011; Arslan & Ergeç, 2010), the Islamic banks are assumed to use three inputs: total funds, labor expense, and fixed assets, to produce two kinds of outputs: net loans by Islamic modes of finance, and other earning assets including equity investments and investment securities. The total funds are the customers' funds, and their unit price is defined as interest expense/deposits. Their share in the total cost is defined as interest expense/total cost, where total cost is equal to the sum of interest expenses, personnel expenditure, and depreciation in addition to other operating expenses. The labor's share of the total cost is personnel expenditure/total cost, and its price is equal to personnel expenditure divided by total assets. This definition of price can be used when data on the number of employees are not readily available. Fixed assets are defined as expenditure on plant and equipment, measured by depreciation plus other capital expenses on the income statement. The capital share of the total cost is non-labor operating expenses/cost, and its price is estimated by the non-labor operating expenses divided by fixed assets. Table 2 summarizes the definition of each variable.

Table 2: Description of Variables

Variable	Symbol	Description
Total cost	C	Interest expense + personnel expenditure + non-labor operating expenses
Net loans	Y1	Net loans by Islamic modes of finance
Other earning assets	Y2	Equity investments + investment securities
Total funds	X1	Total deposits + total borrowed funds
Labor expenses	X2	Total expenditure on employees
Fixed assets	X3	Expenditures on plant and equipment, measured by depreciation + other capital expenses on the income statement
Price of funds	P1	Interest expense/deposits
Price of labor	P2	Personnel expenditure/total assets
Price of non-labor operating expenses	P3	Non-labor operating expenses/fixed assets
Total funds share of the total cost	S1	Interest expenses/ total cost
Labor's share of the total cost	S2	Personnel expenditure/total cost
Capital share of the total cost	S3	Non-labor operating expenses/ total cost

Table 3 highlights the average growth rate for Islamic banks' variables during the period of 2012–2016. Therefore, these statistics show the following:

Table 3: Mean of outputs and inputs, 2012-2016 (in USD million)

Year	Net Loans	Investment Portfolio	Total Funds	Labor	Fixed Assets
	(Y1)	**(Y2)**	**(X1)**	**(X2)**	**(X3)**
2012	1,524.686	813.239	8,000.687	11,435.679	470,056.784
2013	2,240.093	1,179.670	8,999.876	12,000.657	567,890.657
2014	2,471.532	1,348.962	9,000.860	12,435.468	654,783.200
2015	2,707.084	1,888.586	9,111.565	13,000.543	668,965.405
2016	3,156.439	2,056.476	9,125.786	13,021.025	670,000.000

1. For the first output (Y1), the patterns of the contracts (*Murabahah, Salam, Istisna'a* and *Ijara*) highlight an increase from the level of US$ 1,524.7 million in 2012 to the level of US$ 3,156.4 million in 2016, i.e., they increased by 107 percent.
2. With regard to the second output (Y2), which is in the form of sharing in profit and loss (*Musharakah, Mudarabah,* and other Islamic products), it experienced an increase from 813,239 US$ in 2012 to 2,056,476 US$ in 2016, at a growth rate of 153 percent; this is explained by the fact that the volume of Islamic banking operations has developed intensively and significantly across the world throughout this period of time.
3. The mean values of total funds (X1), labor expenses (X2) and fixed assets (X3) have grown steadily during the entire period of study with a superiority of fixed assets.
4. With reference to (Y2), the activities of the Islamic banks based on an investment portfolio were characterized by a great variability over the study period.

Empirical Results

Chaffai (1998) suggests interpreting only the estimated coefficients relating to the allocative inefficiency, since the estimated parameters of the shadow cost frontier are not directly interpretable. The parameters, k_{22} and k_{23}, appearing in the second column of the above table, are positive and significant. As expected, this implies that a good training level improves allocative efficiency. The evolution of allocative inefficiency over time is identified by the coefficients b_2 and b_3, which are negative and significant, suggesting that the allocative efficiency increased over the period of 2005–2009. Erroneous decisions can explain this unexpected result regarding the number used of factors. Table 4 displays the estimation of the shadow cost frontier parameters.

Table 4: Estimation of the cost frontier parameters

Variables	Parameters	Estimation	T-student
constant	α_0	9.755	5.471 *
Lnp_2	δ_1	0,699	3.948 *
Lnp_3	δ_2	0.518	2.538 *
$(Lnp_2 / p_1)^2$	δ_{11}	0.063	2.808 *
$(Lnp_3 / p_1)^2$	δ_{22}	0.064	4.472 *
$(Lnp_2 / p_1)(Lnp_3 / p_1)$	δ_{12}	-0.036	-1.937 **
$Lny_1(Lnp_2 / p_1)$	γ_{11}	0.036	9.732 *
$Lny_1(Lnp_3 / p_1)$	γ_{22}	0.043	3.252 *
$Lny_2(Lnp_2 / p_1)$	γ_{12}	-0.053	-9.455 *
$Lny_2(Lnp_3 / p_1)$	α_1	0.472	6.925 *
Lny_1	α_2	0.055	2.427*
Lny_2	η_{11}	0.011	1.8503**
$(Lny_1)^2$	η_{22}	0.014	1.076
$(Lny_2)^2$	η_{12}	0.019	1.353
$Lny_1 Lny_2$	η_{21}	0.0008	0.126
	b_2	-0.054	-10.66 *
	b_3	-0.038	-10.91 *
	k_{12}	0.909	5.389 *
	k_{22}	0.449	2.229 **
	k_{13}	20.031	9.144 *
	k_{23}	10.142	9.049 *

Note: *, ** significance level at 1% and 5% respectively

The Islamic Banks' Allocative Inefficiency

The allocative efficiency scores of the Islamic banks have been obtained from the estimation of a parametric shadow cost frontier and are depicted in Table 5.

Table 5: Allocative efficiency of Islamic banks

Bank	2012	2013	2014	2015	2016	Mean/bank
1	0,568	0,444	0,498	0,496	0,520	0,505
2	0,515	0,441	0,475	0,455	0,442	0,466
3	0,632	0,439	0,497	0,473	0,460	0,500
4	0,706	0,469	0,521	0,552	0,536	0,557
5	0,777	0,591	0,758	0,793	0,815	0,747
6	0,670	0,504	0,590	0,562	0,604	0,586
7	0,667	0,458	0,528	0,506	0,507	0,533
8	0,577	0,439	0,489	0,469	0,435	0,482

9	0,807	0,596	0,788	0,809	0,646	0,729
10	0,718	0,570	0,648	0,550	0,534	0,604
11	0,810	0,563	0,667	0,638	0,504	0,636
12	0,980	0,830	0,973	0,924	0,364	0,814
13	0,767	0,549	0,658	0,648	0,647	0,654
14	0,878	0,660	0,799	0,795	0,832	0,793
15	0,874	0,571	0,564	0,603	0,556	0,634
16	0,622	0,463	0,526	0,487	0,485	0,517
17	0,636	0,506	0,597	0,497	0,488	0,545
18	0,882	0,583	0,743	0,734	0,745	0,737
19	0,733	0,551	0,656	0,628	0,619	0,637
20	0,610	0,479	0,583	0,541	0,530	0,549
21	0,664	0,502	0,594	0,576	0,527	0,573
22	0,551	0,452	0,510	0,482	0,465	0,492
23	0,779	0,498	0,633	0,573	0,582	0,613
24	0,547	0,438	0,502	0,471	0,465	0,485
25	0,513	0,448	0,490	0,475	0,392	0,464
26	0,513	0,431	0,464	0,448	0,438	0,459
Min.	0,513	0,431	0,464	0,448	0,364	
Max.	0,980	0,830	0,973	0,924	0,832	
Mean/year	0,692	0,518	0,606	0,584	0,544	0,589

Based on our model's estimated coefficients, we can also estimate the coefficients relative to the allocative inefficiency by bank and by period, with reference to Equation (10). The coefficient k_{2it}, which measures the allocative inefficiency relative to the combination of capital and labor inputs, turns out to be inferior to 1 for all banks under study (this coefficient's mean value is equal to 0.498, with a maximum value equal to 0.745 and a minimum value of 0.259). The other factor k_{3it}, which measures the allocative inefficiency relative to the combination of financial and labor factors, is less than 1 (the average coefficient is 0.180, with the maximum being 0.419 and the minimum 0.050). This implies that, over the entire period, no bank has had a coefficient: $k_{ij}(t) = 1, j = 2,3$ i.e., no bank is fully and allocatively efficient over the period of 2013–2016.

Furthermore, it can be inferred that the combinations of inputs, (x_2,x_1), (x_3,x_1), are on average used in the wrong proportions, compared to the optimal combination for minimizing banking costs. Besides, the coefficients $k_{2i}(t)$ and $k_{3i}(t)$ are below unity, highlighting an overuse of the physical capital and financial capital relative to labor. All these noticeable distortions regarding the use of inputs have increased steadily over the period.

One can also derive estimates on coefficient: $k_{23i}(t) = k_{2i}(t)/k_{3i}(t)$, which measures the allocative inefficiency relative to the combination of the x_2 and x_3 factors (physical capital, financial capital). This coefficient is greater than 1, implying that the Islamic banks' allocative inefficiency could be attributed to an overuse of financial resources relative to physical capital.

Finally, note that $k_{3i}(t)<k_{2i}(t)<1$, suggesting that the degree of allocative inefficiency attributed to the combination of financial capital and labor is more important than that associated with a combination of the physical capital and financial capital.

Technical Inefficiency in Islamic Banks

Another source of cost inefficiency is technical inefficiency. This type of inefficiency is estimated according to Equation (14)[1]. Table 6 reports the mean scores of the Islamic banks' technical efficiency over the period of 2012–2016.

Table 6: Islamic bank's technical efficiency 2012-2016

Bank	2012	2013	2014	2015	2016	Mean/bank
1	0,348	0,539	0,658	0,797	0,714	0,611
2	0,484	0,609	0,593	0,560	0,383	0,526
3	0,474	0,499	0,474	0,511	0,467	0,485
4	0,466	0,643	0,753	0,942	0,940	0,749
5	0,242	0,403	0,544	0,747	0,778	0,543
6	0,293	0,507	0,572	0,529	0,299	0,440
7	0,261	0,507	0,653	0,700	0,467	0,518
8	0,357	0,472	0,539	0,667	0,668	0,541
9	0,796	1,000	1,000	1,000	0,747	0,909
10	0,392	0,599	0,600	0,497	0,253	0,468
11	0,360	0,554	0,660	0,763	0,641	0,596
12	0,762	0,343	0,244	0,345	0,726	0,484
13	0,517	0,747	0,807	0,820	0,584	0,695
14	1,000	0,702	0,584	0,724	1,000	0,802
15	0,334	0,509	0,613	0,735	0,654	0,569
16	0,464	0,663	0,742	0,817	0,660	0,669
17	0,311	0,525	0,612	0,617	0,402	0,493
18	0,310	0,397	0,427	0,487	0,438	0,412
19	0,223	0,356	0,412	0,433	0,309	0,347
20	0,456	0,589	0,600	0,606	0,453	0,541
21	0,383	0,573	0,638	0,664	0,483	0,548
22	0,363	0,575	0,683	0,762	0,598	0,596
23	0,429	0,399	0,416	0,614	0,954	0,562
24	0,358	0,592	0,662	0,630	0,381	0,525
25	0,334	0,497	0,566	0,620	0,488	0,501
26	0,262	0,535	0,694	0,719	0,444	0,531
Min	0,223	0,343	0,244	0,345	0,253	
Max	1,000	1,000	1,000	1,000	1,000	
Mean/year	0,422	0,551	0,606	0,666	0,574	0,564

It is noteworthy that the average technical efficiency of the studied banks has increased over the first three years but has declined during the last two years. Furthermore, we record that, on average, all Islamic banks appear to be technically inefficient. The average value of technical efficiency for the entire period was 44.6 percent. This low score is not consistent with that achieved by other studies on Islamic banking; for instance, Donsyah (2004) reported a technical efficiency of about 90 percent. This is mainly because the author adopted a non-parametric based DEA approach as well as a different sample. Our result is, however, consistent with the results of Hassan (2006), who reported an average technical efficiency ranging between 0.109

[1] The Fisher test shows that technical efficiency is variable over time. Thereby, the assumption of the invariability over time of technical inefficiency is rejected.

and 1. The impact of technical and allocative inefficiencies on cost has also been estimated using Equation (17). The scores are depicted in Table 7.

Table 7: Islamic bank's cost efficiency

Bank	2012	2013	2014	2015	2016	Mean/bank
1	0,198	0,239	0,328	0,395	0,371	0,306
2	0,249	0,269	0,282	0,255	0,169	0,245
3	0,300	0,219	0,236	0,242	0,215	0,242
4	0,329	0,302	0,392	0,520	0,504	0,409
5	0,188	0,238	0,412	0,592	0,634	0,413
6	0,196	0,256	0,337	0,297	0,181	0,253
7	0,174	0,232	0,345	0,354	0,237	0,268
8	0,206	0,207	0,264	0,313	0,291	0,256
9	0,642	0,596	0,788	0,809	0,483	0,664
10	0,281	0,341	0,389	0,273	0,135	0,284
11	0,292	0,312	0,440	0,487	0,323	0,371
12	0,747	0,285	0,237	0,319	0,264	0,370
13	0,397	0,410	0,531	0,531	0,378	0,449
14	0,878	0,463	0,467	0,576	0,832	0,643
15	0,292	0,291	0,346	0,443	0,364	0,347
16	0,289	0,307	0,390	0,398	0,320	0,341
17	0,198	0,266	0,365	0,307	0,196	0,266
18	0,273	0,231	0,317	0,357	0,326	0,301
19	0,163	0,196	0,270	0,272	0,191	0,219
20	0,278	0,282	0,350	0,328	0,240	0,296
21	0,254	0,288	0,379	0,382	0,255	0,312
22	0,200	0,260	0,348	0,367	0,278	0,291
23	0,334	0,199	0,263	0,352	0,555	0,341
24	0,196	0,259	0,332	0,297	0,177	0,252
25	0,171	0,223	0,277	0,295	0,191	0,231
26	0,134	0,231	0,322	0,322	0,194	0,241
Min	0,134	0,196	0,236	0,242	0,135	
Max	0,878	0,596	0,788	0,809	0,832	
Mean/year	0,302	0,285	0,362	0,388	0,319	0,331

One might well notice that, on average, the banks' cost efficiency appears to be quite small, varying between 13.4 percent in 2012 and 83.2 percent in 2016. As we can see, on average, Islamic banks have experienced an increase in total costs due to cost inefficiencies of the order of 66.88 percent. This increase is, simultaneously, due to allocative and technical inefficiency deterioration. It is noticeable that a slight improvement in technical efficiency did occur, increasing from 42.4 percent in 2012 to 66.6 percent in 2015. At the end of the period, the two cost inefficiency components have, though unequally, contributed to the overall cost efficiency, with 54.4 percent and 57.4 percent.

Applying the shadow cost frontier model has shown that Islamic banks are both technically and allocative inefficient. The allocative inefficiency varies over time, and it is not constant for all the banks which are the subject of study. The allocative inefficiency appears to engender an overuse of financial resources and of physical capital relative to labor, while the financial factor is overused in respect of physical capital. We have also shown that the managers' proportion in terms of payroll has had a positive effect on allocative efficiency. Also, the technical inefficiency appears to be the second primary source of economic inefficiency regarding the Islamic banks' cost. The results have demonstrated that both the technical and allocative inefficiencies turn out to be very important as assessment tools insofar as Islamic banking is concerned.

CONCLUSION

The measurement of cost efficiency and its two components technical inefficiency and allocative inefficiency has been carried out successfully, in the present paper. Our empirical results show that the method of shadow cost frontier is effective to distinguish between technical and allocative efficiencies. The parameter estimates are plausible, reliable, and satisfy all theoretical requirements. Applying the shadow cost frontier to a sample composed of 26 Islamic banks revealed that they were technically inefficient. It is interesting to note that the allocative and technical inefficiencies appear to be time-variant and bank-specific. As regards to allocative inefficiency, it can be explained by the excessive use of capital relative to labor, accompanied by an overuse of financial resources in terms of labor. The financial factor is overused relative to the physical capital, while the technical inefficiency appears to be the second source of cost inefficiency as far as the Islamic banks are concerned. Overall, the findings indicate that technical inefficiency is the major source of inefficiency, meaning that the Islamic banks must improve their use of resources by about 43.7 percent so that an efficient level could be reached.

The findings of the present paper provide insights for Islamic banks' managements and regulators, by suggesting the best allocation of resources and optimal use of capacity and high quality of management. The policy implication for the managers and regulators of Islamic banks is that Islamic banks' management should emphasize more on improving their managerial performance and practices rather than on increasing the scale of operations. We also advise that supervisory authorities should undertake various regulatory and financial measures to boost the development of Islamic banking and ensure the sustainable growth of the Islamic banking industry and increase its market share. For future research, more Islamic banks could be studied, taking into consideration some additional input and output variables.

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