THE INTERNATIONAL JOURNAL OF BUSINESS & MANAGEMENT

Cost Efficiency and Credit Risk: A Comparative Study between Islamic and Conventional Banks in the GCC Countries

Mohamed Ghroubi
Assistant Professor of Finance, Department of Islamic Sciences,
Higher Institute of Theology, Ez-Zitouna University, Tunisia
Ines Ben Teber
Technologist, Department of Economics and Management,
Higher Institute of Technological Studies, Jendouba, Tunisia
Kais Ayachi
Assistant Professor, Department of Civil Engineering, Higher Institute of Environmental,
Planning and Building Technologies, Carthage University, Tunisia

Abstract:
This study aims to examine the relationship between cost efficiency and risk in Islamic and conventional banks of the Gulf Cooperative Council countries over the period 2006-2015. The sample is composed of 99 commercial banks divided into 51 conventional banks and 48 Islamic banks. To achieve this, we have used stochastic frontier in the first stage and meta-frontier analysis in the second stage to calculate efficiency scores. The GMM model is used to examine the relationship between cost efficiency and credit risk.
The specific as well as common frontiers obtained by the stochastic frontier method and meta-frontier analysis show the superiority of conventional banks compared to Islamic banks in terms of cost efficiency. Moreover, descriptive statistics show that Islamic banks are more liquid, more exposed to credit risk and more capitalized than conventional banks. The regression estimation further indicated a positive and significant effect of the credit risk on cost efficiency obtained by the stochastic frontier of Islamic banks, and a negative one in the case of conventional banks. The common frontier reveals no significant effect. However, this study proves that credit risk has a positive and significant relationship with the cost efficiency of Islamic and conventional banks obtained by the meta-frontier analysis. This study shows that the choice of the evaluation method of the efficiency scores can influence the results obtained. As for the impact of the regulatory capital ratio, it is found to be positively correlated with the cost efficiency of both categories of banks.

Keywords: Islamic banks, conventional banks, cost efficiency, SFA, meta-frontier analysis, credit risk.

1. Introduction

The subprime mortgage crisis has revealed all the weaknesses of the conventional financial system, and drawn attention to the Islamic financial system as a substitute. In this respect, researchers have demonstrated that Islamic banks had been more resilient and stable than their conventional counterparts during the subprime crisis (Hasan and Dridi, 2010); (Ftiti et al., 2013); (Farooq and Zaheer, 2015)). Several authors argue that this resilience is attributed to the nature of their business model. Chapra (2008) specifies that the subprime crisis would not have occurred with an Islamic financial system. He adds that the operations causing the development and spread of this crisis are not permissible under the rules and directives of Sharia.

Nevertheless, Johnes et al. (2013) suggest that despite the resilience of Islamic banks during the financial crisis, their performance is expected to be inferior to that of conventional banks. In addition, empirical work carried out on Islamic bank efficiency shows mixed results. While some studies have demonstrated a non-significant difference between both types of banks ((Hassan et al. 2009); (Shahid et al., 2010)), others have supported the hypothesis of a low efficiency for Islamic banks compared to conventional ones ((Abdul-Majid et al. 2010); (Johnes et al., 2009) ;(Abdul-Majid et al., 2008, 2011a, b); (Beck et al., 2013)). More recent research explains the delay in terms of efficiency by the fact that Islamic banks hold higher equity. On this matter, Khediri et al., (2015) suggest that it is useful that these banks maintain higher capital buffers in order to mitigate liquidity risks.

In addition, other researchers have used a comparative approach in order to study the major determinants of efficiency, and analyze the incidence of the different risk indicators ((Alam, 2012); (Setiawan et al. 2013); (Saeed and Izzeldin, 2014); (Louhichiand Boujelbene, 2015); (Dulal Miah and Uddin 2017)). In fact, despite their functional specificities, Islamic banks remain vulnerable to common banking risks, and specifically to the risks related to their intermediation role that can affect their efficiency. According to Ariffin et al., (2009), Islamic and conventional banks face similar risks, though their scope may differ depending on the type of bank. Hussain et Al-Ajmi (2012) have noted that the key risks to which Islamic and conventional banks are exposed are credit risk, liquidity risk, and operational risk.

In the previous comparative studies, efficiency calculation generally referred to the financial ratio analysis and to the distance frontier approach. One of the major disadvantages of the application of the ratio model in connection with Islamic banks is its underlying cost minimization or profit maximization hypothesis that cannot be the only objective in such case. In the present paper, we therefore give priority to Stochastic Frontier Approach (SFA) for the study of the relationship between credit risk and efficiency based on a sample of Islamic and conventional banks of the Gulf Cooperation Council (GCC) region. The contribution of this work lies in the use of the meta-frontier method ((Johnes et al., 2013); (Ghroubi and Abaoub, 2016a)) for the decomposition of efficiency into two components: one caused by the modus operandi, reflecting the context in which the banks (Islamic and conventional) operate, and the other reflects the managerial competence of converting inputs into outputs.

In order to meet that objective, the paper will be organized as follows: introduction; section 2 is devoted to the literature review and hypothesis statement. Data and methodology are described in section 3. Section 4 includes a presentation and discussion of findings. The conclusion is presented in the last section.

2. Literature Review and Hypothesis Statement

2.1. Literature Review

The interest given to the study of the relationship between efficiency and risk has considerably increased especially in the aftermath of the so-called subprime crisis. Most of the studies focused on the relationship between efficiency and credit risk measured by the proportion of non-performing loans or by the loan loss provisions. Sun and Chang (2011) have widely criticized the general trend of these studies, which overlooked the importance of the other types of risk, such as liquidity risk and market risk.

On the practical level, analysis of this relationship has required the use of different methods. By using Granger Causality Test, several studies have shown that cost-efficiency reductions precede the appearance of non-performing credits((Berger and De Young, 1997); (Williams, 2004); (Podpieraand Weill, 2008);(Fiordelisi et al.,2011)).This finding can be justified by the bad management hypothesis proposed byBerger and De Young (1997). The positive relationship between cost inefficiency and risk taking is also validated by Kwan and Eisenbeis (1997)through a simultaneous equation model.By integrating non-performing loans into the production function, Hughes et al., (1994) hold an opposing view by supporting the hypothesis according to which there exists a negative relationship between inefficiency and risk taking. Based on a risk aversion hypothesis, these authors suggest that managers incur additional expenses when providing the loans and monitoring repayment performance. By using Seemingly Unrelated Regressions (SUR), Altunbas et al., (2007) show that the most inefficient European banks hold highercapital levels, and have lower credit risks, while the most efficient banks tend to take more risks. Similarly, Deelchandand Padgett (2009) provide evidence of the existence of a negative relationship between risks, measured by a loan loss provisions, and capital. In addition, their findings make it clear that inefficient banks operate with more capital while maintaining a high level of credit risk.

The study of the relationship between efficiency and risk has also been carried out by integrating various aspects of risk into the production function. Mester (1996) and Hughes et al., (2001) indicate that failure to ensure adequate consideration of risk may have a significant impact on efficiency scores. Hughes andMester (1993, 1998) have applied the parametric method by integrating two risk indicators into the production function, namely the quality of the assets, measured by the proportion of non-performing loans and equity level.According to Hughes and Mester (1993, 1998), equity can be a source of loan able funds and is considered a buffer against liquidity risk. Altunbas et al., (2000) integrate loan loss provisions, financial capital and liquidity ratio into their estimation of cost-efficiency frontier in order to examine the impact of risk factors and asset quality on Japanese commercial bank costs between 1993 and 1996. This study shows the close connection between the scope of the economies of scale, and risk factors. In addition, results prove that the financial capital level has a significant influence on efficiency estimates. More recent work suggests also that failure to consider risks may lead to biased estimates of bank efficiency, scale economies, and cost-elasticity ((Koetter,2008); (Hughes and Mester, 2013); (Malikov et al.,2014)). Furthermore, Pessarossi and Weill (2015) note that a higher capital ratio causes an increase in cost-efficiency for Chinese banks for the period 2004 to 2009.Nguyen and Nghiem (2015) make it clear that a decrease in cost-efficiency is followed by an increase in insolvency risk (bad management hypothesis), whereas a rise in insolvency risk in public banks is generally followed by a decrease in cost-efficiency (Bad luck hypothesis). Over the period extending from 2003 to 2013, Tan (2016) studied the relationship between different types of risk (credit risk, liquidity risk, capital risk, and insolvency risk) and efficiency, based on a sample of Chinese commercial banks. Results show that credit risk is negatively linked to cost-efficiency and profit-efficiency. Besides, a positive and significant relationship between insolvency risk and cost-efficiency has been proven. However, the study did not show any significant impact of liquidity risk and capital risk on cost-efficiency.

The issue of the relationship between efficiency and riskhas also been addressed when comparing Islamic and conventional banks. The results obtained were heterogeneous. Alam (2012) has studied this relationship based on a sample of Islamic and conventional banks, and has demonstrated the existence of a positive correlation between inefficiency and risk in conventional banks, and a negative one in Islamic banks. Based on the Ratio method, Beck et al., (2013) show that Islamic banks are less efficient, have more capital, and, during the subprime crisis, have succeeded in havinga better quality of assets. Using the Stochastic Frontier analysis and the vector autoregressive methodology, Saeed andIzzeldin (2014) discussed the possibility that a causal relationshipexists between efficiency and default risk measured by distance-to-default. Analysis of results shows that for both types of banks, an increase in cost-efficiency causes an increase in default risk (decrease in distance-to-default). Thus, according to this study, default risk and efficiency measurements can serve as an early warning indicator to avoid any possible banking crisis.

Based on Zellner's SUR model, Louati et al., (2016) have assessed the relationship between risk, capital and efficiency through a comparative study between Islamic and conventional banks in countries of the MENA region and in Asia. Among the explanatory variables of cost-efficiency, the study has taken into consideration the effects of credit risk, insolvency risk, and liquidity level. The results obtained make it clear that variation in the cost-efficiency of Islamic banks andthatof conventional banks, following variation in insolvency risk and liquidity level, are not the same. However, the cost-efficiency of both types of banks varies in the same way, following variation in credit risk. Using the Stochastic Frontier Analysis(SFA) and Ordinary Least Square (OLS), DulalMiah and Uddin (2017) confirm that conventional banks are more efficient than Islamic banks, and that the latter are more stable in the short term, while no difference is found in the long term. Results show also that the best capitalized banks have the highest inefficiency scores.

It is to be noted that the efficiency measurement in these recent studies is generally determined on the basis of accounting ratios or the SFA method. Another study group deserves special attention as long as it distinguishes between gross efficiency and net efficiency when comparing efficiency in Islamic as well as conventional banks ((Abdul-Majid et al.,2008); (Johnes et al., 2009); (Abdul-Majid et al.,2010, 2011a, b)).Gross efficiency takes into account managerial competence as well as the efficiency of the modus operandi. Net efficiency isolates the managerial component and subsequently provides measurement of managerial efficiency. Along the same lines, Johnes et al., (2013) and Ghroubi and Abaoub (2016)have attempted to develop an overall efficient frontier on the basis of meta-frontier analysis. This method makes it possible to compare several producer groups operating in different technologies by calculating a technological gap ratio, which defines the overall cost-efficiency scores based on specific efficiency scores. Therefore, these studies are of interest to us and offer us another way of evaluating the relationship between efficiency and risk in a dual banking system. This approach does not impose any underlying hypothesis concerning the banks' objectives and takes into account differences of interbank perspectives.

2.2. Hypothesis Statement
In the present work, we plan to test the following hypotheses:
- H1: Islamic banksare less efficient than conventional banks;

Johnes et al. (2013) attribute the poor performance of Islamic banks to three main reasons: (1) the diversity of Islamic jurisprudence schools,which raises the issue of Islamic bank product standardization; (2) the size factor, which may be equally decisive; and (3) the fact that Islamic banks are often domestic banks, although most empirical evidence ((Isikand Hassan,2002); (HasanandMarton, 2003); (KasmanandYildrim, 2006); (Matthews and Ismail, 2006); (Mokhtar et al.,2008))makes it clear that foreign banks have a higher cost-efficiency than domestic banks.

- H2: An increase in credit risk entailsa decrease in cost-efficiency. This hypothesis remains valid as much in the case of Islamic banks as in the case of conventional banks.

This hypothesis can be explained by the Bad Luck hypothesis (Berger and De Young,1997)which stipulates that credit risk has a significant and negative impact on efficiency. According to this hypothesis, exogenous events such as regional economic downturns affect the quality of assets by raising problem loans, and make insolvency risk more cumbersome. Bank managers should expend management effort and incur additional expenditure, such as loan monitoring andforfeiture of securities to remedy this unfavorable situation. Consequently, banks bear additional operating costs, and lose some revenues, which entail a deterioration of cost and profit efficiency.

3. Database and Methodology

3.1. Database
The sample consists of 99 commercial banks of the Gulf Cooperative Council (GCC) countries, divided into 51 conventional banks and 48 Islamic banks. The study period extends from 2006 to 2015. The total number of observations has been fixed to 731, of which436 observations are attributed to conventional banks, and 295 to Islamic banks. Data have been taken from Bankscope database. The numbers of banks by country and by category (Islamic or conventional) as well as the number of observations for each country are described in table 1.

Country	Conventional banks		Islamic banks		All banks	
	Number of Banks	No. of Observations	Number of Banks	No. Of Observations	Number Of Banks	No. of Observations
KSA	8	80	5	44	13	124
KUWAIT	5	47	10	58	15	105
UAE	16	141	8	64	24	205
BAHRAIN	11	65	19	98	30	163
QATAR	5	46	4	26	9	72
OMAN	6	57	2	5	8	62
Total	51	436	48	295	99	731

Table 1: Description of the Study Sample

3.2. Methodology
In this paper, we will proceed through three stages: in the first stage, we use the specific stochastic frontiers to calculate efficiency scores. In the second stage, we use the meta-frontier analysis to determine an overall efficiency

frontier. The study of the relationship between cost efficiency and creditrisk through the dynamic GMM panel techniques dealt with in the last stage.

- 1st stage: The use of the Stochastic Frontier Approach (SFA) to determine a cost-efficiency frontier specific to each category of bank

Developed by Aigner et al., (1977) and Meeusen and Van Den Broeck (1977), the Stochastic Frontier Approach (SFA) is one of the parametric methods designed to evaluate cost efficiency. This parametric approach assumes the decomposing of estimation errors in two components: One component for the random errors caused by measurement errors and exogenous shocks; the other component for inefficiency measurement specific to each entity to be evaluated. According to Berger and Mester (1997), cost efficiency is a measure of the distance between the actual production cost of an output basket of bank i and the production cost of a best practice bank operating under similar conditions. Cost-efficiency evaluation allows us to know the actual cost deviation of an output basket, compared to the minimum production cost of the same basket. SFA determines efficiency scores based on a stochastic frontier cost function that can be expressed, in the case of a sample consisting of N banks, in the following manner:

$$\text{LN TC}_I = F(Y_I, P_I, B) + E_I, \quad \text{WITH } E_I = U_I + V_I \quad (1)$$

Where:

$\ln TC_i$: Total cost of bank i

Y : Bank i output vector

P : Bank i input vector

β : Vector of parameters to be estimated.

ε_i : Error component

The error term ε_i is decomposed into two parts: u_i capturethe effect of technical and al locative inefficiency; v_i is the stochastic error reflecting measurement errors and exogenous shocks. The two error terms are supposed to be independent. In addition, the v_i are supposed to be identically and independently distributed (iid) following a normal law of a mean equal to 0 and a variance equal to σ_v^2. The u_i are frequently supposed to follow a semi-normal distribution, that is to say $u_i \sim N^+(m, \sigma_u^2)$, where m designates the inefficiency mean. The cost frontier is estimated via the method of maximum likelihood defined byBatteseandCoelli (1995), and the efficiency levels are deducted from the regression error as follows:

$$CE_{it} = \frac{1}{\exp(\hat{u}_i)} = \exp(-\hat{u}_i).$$

As far as the selection of the model variables are concerned, we adopt the intermediation approach proposed by Sealey and Lindley (1977), which considers deposits among the inputs of a bank, together with work and capital. Moreover, outputs are measured by value rather than by the number of accounts managed by the bank. Therefore, total cost takes into consideration interest costs in addition to personnel costs and other operating expenses. Thus, in order to calculate the cost-efficiency scores, three inputs and two outputs are retained. The three production factors are, respectively, the physical capital (K), the financial capital (F) and work (W). The two outputs under consideration are: total credits (Y1) and total equity portfolio (Y2). Based on the translog functional form, the model to be estimated reads as follows:

$$LnCT_{it} = \beta_0 + \sum_{k=1}^{2} \beta_k \ln(Y_{kit}) + \sum_{h=1}^{3} \alpha_h \ln(P_{hit}) + \frac{1}{2}\sum_{j=1}^{2}\sum_{k=1}^{2} \beta_{jk} \ln(Y_{jit})\ln(Y_{kit}) + \frac{1}{2}\sum_{h=1}^{3}\sum_{j=1}^{3} \alpha_{hj} \ln(P_{hit})\ln(P_{jit}) +$$
$$\sum_{j=1}^{3}\sum_{k=1}^{2} \lambda_{jk} \ln(P_{jit})\ln(Y_{kit}) + \varepsilon_{it} \quad (2)$$

Where ivaries between 1 and N (N is the total number of banks in the sample); t represents the year which varies between 1 and 10; h varies between 1 and 3 and represents the price of inputs; k varies between 1 and 2 and represents the number of outputs. Following the restrictions imposed by the constraints of symmetry and homogeneity, the number of coefficients to be estimated will be reduced to 21 instead of 34.

This model should be used to identify two specific cost-efficiency frontiers and one common frontier. The first frontier is representative of Islamic banks; the second frontier is that of conventional banks, while the third combines the two types of banks.

- 2nd Stage: The Principle of Meta-Frontier Analysis (MFA)

In order to take account of the specificities of the Islamic banks' operation in comparison with conventional banks, we have decided to broaden our analysis of cost-efficiency measurement by trying to make the best of the propositions of Battese et al., (2004) who succeeded in developing a meta-frontier production function to correct efficiency measurement errors caused by the technological and operational gap.MFA makes it possible to compare several producer groups involved in different technologies by calculating a technological gap ratio that allows us to determine the overall cost-efficiency scores, based on the specific cost-efficiency scores.

On the basis of the contributions by Battese et al., (2004), Huang et al., (2011) have attempted to construct a cost frontier which envelopes all stochastic cost frontiers of the different European banking groups. Estimation of the meta-frontier cost function parameters (φ^*) requires the resolution of the following system:

$$\text{Min L}^* \equiv \sum_{t=1}^{T}\sum_{i=1}^{N} |\text{Inf}(X_{it}, \hat{\varphi}_{(r)}) - \text{Inf}(X_{it}, \varphi^*)|, \quad u/c \text{ Inf}(X_{it}, \varphi^*) \leq \text{Inf}(X_{it}, \hat{\varphi}_{(r)}) \quad (3)$$

By taking system constraints into account, the absolute value can be removed, which amounts to resolving the following problem:

$$\text{Min L}^* \equiv \sum_{t=1}^{T}\sum_{i=1}^{N} [\text{Inf}(X_{it}, \hat{\varphi}_{(r)}) - \text{Inf}(X_{it}, \varphi^*)], \quad u/c \text{ Inf}(X_{it}, \varphi^*) \leq \text{Inf}(X_{it}, \hat{\varphi}_{(r)}) \quad (4)$$

Considering that i: 1,..., N(all the banks of the sample considered); t:study period; r: group 1 or group 2, (r = 1: Islamic banks group; r = 2: conventional banks group); X_{it} is the input and output vector; f is the cost function; $\hat{\varphi}_{(r)}$ is the vector of

parameters estimated on the basis of individual cost functions; φ^* is the vector of meta-frontier cost function parameters to be estimated. These parameters are set in such a way that $X_{it}\varphi^* \leq X_{it}\varphi_r$.

The objective of the minimization problem is to reduce as much as possible the distance between cost efficiency determined by the stochastic cost function of each group, and the minimum cost efficiency calculated by the meta-frontier function. The meta-frontier function $\ln f(X_{IT}, \Phi^*)$ takes the same form as that of the individual stochastic cost frontiers. Moreover, the resolution of the problem of minimization will be ensured by the use of an optimization technique based on genetic algorithm.

Following estimation of the meta-frontier function parameters, the measurement of the overall cost efficiency (OCE) for bank i, at time t, belonging to group r is formulated by the ratio of minimum cost efficiency (determined by meta-frontier) and the observedcost efficiency (calculated on the basis of individual cost functions), adjusted by the corresponding random error:

$$OCE_{it(r)} = e^{-U_{it(r)}} \times \frac{e^{X_{it}\varphi^*}}{E^{X_{it(r)}\varphi_r}} \quad (5)$$

Where, $E^{-U_{IT(R)}}$, is the cost efficiency related to the stochastic frontier of group r. It measures the distance between the observed cost of bank (i) and the stochastic cost frontier of group r. The second term of the equation on the right is the technological gap ratio. Graph (1) shows the principle of the meta-frontier function.
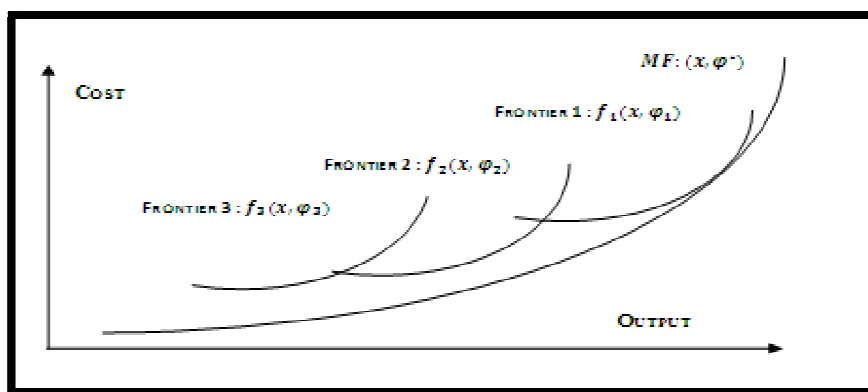

Figure 1: Meta Frontier Function
Source: Huang et al. (2011)

- 3rd stage: Study of the relationship between cost efficiency and credit risk

The study of the relationship between cost efficiency and credit risk requires the estimation of the following model:

$$CE_{it} = \alpha + \beta\, CE_{i,t-1} + \gamma\, X_{it} + \varepsilon_{i,t} \quad (6)$$

Where i : 1,...., N, represents the banks ; t : 1,....., T represents time; CE_{it}: dependent variable representing in a first step the cost-efficiency scores determined on the basis of specific stochastic frontier, and in a second step the cost-efficiency scores calculated on the basis of the meta-frontier function; CE_{it-1}:delayed variable of efficiency scores; $\varepsilon_{i,t} \sim IID(0,\sigma_\varepsilon^2)$ represents the model's error or the unidentified random variations; $X_{it}$is the vector of the variables representative of credit risk, liquidity, and regulatory capital. The model variables are summarized in table 2 below.

The capital is retained since it is considered among the most determinant variables of efficiency ((Hughes and Mester, 1993, 1998), (Pessarossi and Weill, 2015) while the introduction of the liquidity level makes it possible to identify the effect of surplus liquidity, one of the features of Islamic banks' activities (Hassan and Dridi (2010); (Trad et al., 2017)), on cost efficiency.

The estimation of the model's parameters will be ensured by a GMMdynamic panel proposed by Arellano and Bond (1991), and later developed by Arellano and Bover (1995) and Blundell and Bond (1998). This method makes it possible to solve all end ogeneity problems, not only at the level of efficiency variable, but also at the level of other explanatory variables by using a series of instrumental variables generated by the variable lags. The GMM method allows us also to study the effect of delayed dependent variable, and seems to be most appropriate for unbalanced data. In addition, this research refers to the two-stage GMM method, with robust standard errors in order to resolve the error heteroskedasticity and autocorrelation problems.

Variables	Definition		Studies
	Dependent variables		
Cost efficiency SFA	Efficiency scores calculatedaccording to SF approach	CE_1	Carvallo and Adnan, 2005; Pessarossi and Weill, 2015 Dulal Miah and Uddin,2017
Cost efficiency MF	Efficiency scores calculated according to MF approach	CE_2	Johnes et al., 2013 Ghroubi and Abaoub 2016
	Explanatory variables		
Credit risk	Impaired loans (NPLs)/Gross loans	NPLS	Berger and DeYoung,1997 ; Altunbas et al., 2000 ; Fiordelisi et al., 2011; Beck et al., 2013 ; Kabir et al., 2015 ; Louati et al., 2016;Mohanty et al., 2016
Liquidity ratio	Liquidity assets ratio= Liquid assets / Deposits and short-term funding	LAR	Ben Mbarek et al., 2015 Trad et al., 2017 ; DulalMiah and Uddin.,2017
Risk weighted capital ratio	Eligible capital/Total risk-weighted assets	RWCR	Mohanty et al., 2016 ; Ghroubi and Abaoub, 2016 Tan and Anchor, 2017

Table 2: Description of model variables

4. Presentation and Analysis of Results

4.1. Analysis of Efficiency Score Estimation Results

As far as the estimation of stochastic frontier models is concerned (see Appendix, Table AI), the results of the chi-square test prove that these models have a sufficient explanatory power. The parameters of the common stochastic frontier show that an increase in the cost of financial capital, as well as of work, causes a decrease in total cost; while the estimated parameters of meta frontier make it clear that the decrease in total cost may be the result of an increase in the cost of financial capital and/or of the amount of securities portfolio.

The estimation of efficiency scores by means of stochastic frontier models (table 3 and graph 2) supports Hypothesis H1 according to which Islamic banks are less efficient than conventional banks. This hypothesis is also confirmed by the cost-efficiency scores obtained following the estimation of the meta-frontier function parameters(table 3 and Figure 3).

Year	Stochastic Frontier				Meta Frontier				
	Islamic banks		Conv. Banks		Islamic banks		Conv. Banks		
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
2006	0,832	0,139	0,967	0,034	0,673	0,191	0,765	0,069	
2007	0,826	0,124	0,951	0,045	0,667	0,187	0,753	0,085	
2008	0,820	0,152	0,960	0,034	0,679	0,165	0,769	0,077	
2009	0,819	0,148	0,963	0,330	0,647	0,157	0,784	0,085	
2010	0,845	0,123	0,958	0,034	0,680	0,136	0,795	0,073	
2011	0,830	0,171	0,964	0,027	0,669	0,195	0,794	0,089	
2012	0,825	0,168	0,960	0,034	0,649	0,209	0,794	0,080	
2013	0,837	0,169	0,957	0,038	0,646	0,223	0,802	0,073	
2014	0,829	0,177	0,960	0,035	0,684	0,167	0,809	0,075	
2015	0,857	0,181	0,954	0,044	0,719	0,165	0,804	0,081	

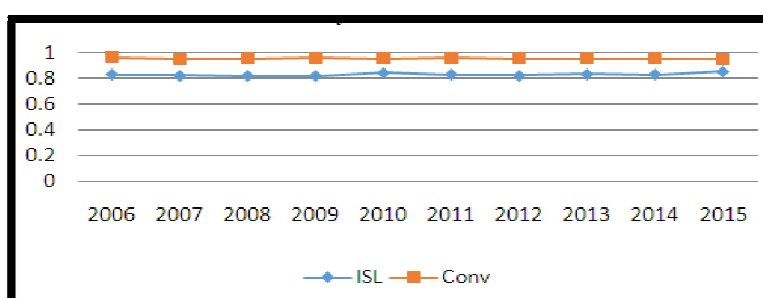*Table 3: Descriptive Statistics of Cost Efficiency by Year and Banks Categories*

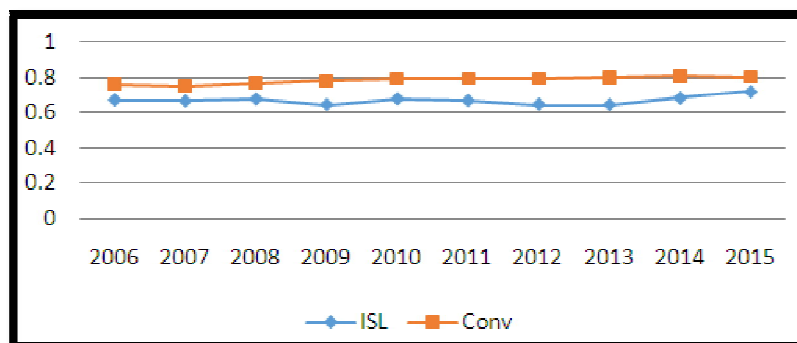*Figure 2: Annual Average of Cost Efficiency Scres Measured by the SFA*

Figure 3: Annual Average of Cost Efficiency Scres Measured by the MFA

It is to be noted that the difference between the efficiency scores of Islamic banks and conventional banks has been reduced in moving from the stochastic frontier to meta frontier. Figure 4shows that this result is explained by the evolution of the average of the technology gap ratio. In fact, over the period 2006-2015, Islamic banks had an average ratio of technology gap almost equal to that of conventional banks, which proves that the two types of banks adopt the same modus operandi. The difference, in terms of efficiency, between the two types of banks is due to matters of managerial competence.
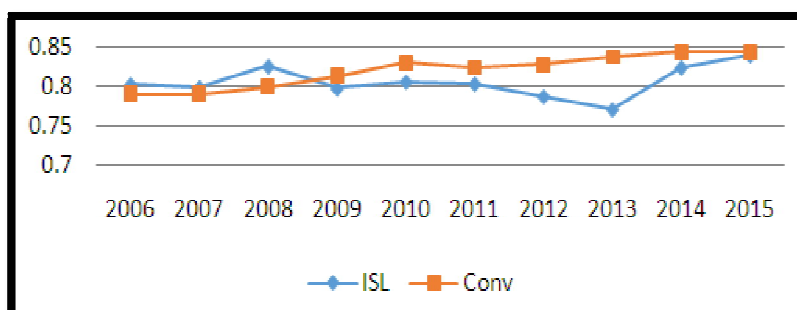

Figure 4: Annual Average of the Technology Gap Ratio

The study of efficiency scores by country (Table 4), calculated on the basis of stochastic frontier, shows that UAE and Qatar's Islamic banks are more efficient than conventional banks, and that the mean difference is statistically significant. This difference is insignificant with Omani banks. Calculation of efficiency scores according to the meta frontier makes it clear that only Qatari Islamic and conventional banks have non-significant difference of means.

Country	Stochastic Frontier					Meta Frontier				
	Islamic banks		Conv. Banks		Difference of means	Islamic banks		Conv. Banks		Difference of Means
	Mean	Std. Dev.	Mean	Std. Dev.		Mean	Std. Dev.	Mean	Std. Dev.	
KSA	0,898	0,059	0,924	0,043	0.0066	0,750	0,078	0,854	0,058	0,0000
KUWAIT	0,740	0,265	0,891	0,063	0.0002	0,595	0,262	0,786	0,087	0,0000
UAE	0,933	0,030	0,922	0,034	0.0314	0,734	0,106	0,769	0,063	0,0035
BAHRAIN	0,828	0,130	0,902	0,071	0.0000	0,614	0,178	0,791	0,112	0,0000
QATAR	0,945	0,023	0,920	0,041	0.0050	0,772	0,059	0,780	0,076	0,6411
OMAN	0,938	0,023	0,931	0,021	0.4937	0,565	0,218	0,746	0,039	0,0000

Table 4: Descriptive Statistics of Cost Efficiency by Country and Banks Categories

The ranking of GCC countries according to the average of cost-efficiency scores of all the Islamic and conventional banks (Table 5), calculated on the basis of stochastic frontiers, shows that Oman has the most efficient banking system. The application of meta frontier encourages Saudi banks.

Country	Stochastic Frontier			Meta Frontier		
	All banks			All banks		
	Mean	Std. Dev.	Ranking	Mean	Std. Dev.	Ranking
KSA	0,915	0,051	4	0,817	0,082	1
KUWAIT	0,808	0,215	6	0,680	0,224	6
UAE	0,925	0,033	3	0,758	0,080	3
BAHRAIN	0,857	0,116	5	0,685	0,177	5
QATAR	0,929	0,037	2	0,777	0,070	2
OMAN	0,932	0,021	1	0,731	0,084	4

Table 5: Descriptive Statistics of Cost Efficiency by Country

4.2. Analysis of the Relationship between Cost Efficiency and Credit Risk

Descriptive statistics (Table 6) show that the average of the non-performing credit ratio of Islamic banks is higher than that of conventional banks. In return, Islamic banks have higher levels of liquidity and regulatory capitals than conventional banks. All the differences of means are statistically significant.

Ratios	Islamic Banks/ 2006-2015				Conv. banks/ 2006-2015				Difference of Means
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	p-value
Eff (SF)	0,83162	0,156816	0,049883	0,980930	0,959513	0,035907	0,757410	0,99350	0,0000
Eff (MF)	0,66970	0,182018	0,004834	0,965082	0,787761	0,080228	0,361536	0,96815	0,0000
RWCR	26,4590	21,93294	8,370000	204,4100	18,54016	5,412237	0,650000	50,1100	0,0000
NPLS	6,15051	10,04547	0,000000	57,69000	4,447954	4,776237	0,050000	30,3300	0,0042
LA	67,6526	131,5290	0,156000	997,7180	25,26173	13,39745	0,855000	92,6240	0,0000

Table 6: Descriptive Statistics of Regressions Variables

Model specification tests (Table7) are used to study the error autocorrelation and heteroskedasticityproblems. Rejection of the null hypothesis of Wooldrige test (2002) indicates the existence of first order autocorrelation. As to error heteroskedasticity, results of the Breusch and Pagan (1979) test and the Likelihood Ratio test, of which the null hypothesis is in favor of error heteroskedasticity, show that hypothesis H0 is rejected, which proves the presence of an error heteroskedasticity problem. Moreover, VIF[1] test results show the absence of any multicollinearity problem (Table 8).

	Stochastic Frontier						Meta Frontier					
Islamic Banks		Conv. Banks		All Banks		Islamic Banks		Conv. Banks		All Banks		
Wooldridge test for autocorrelation in panel data, H0: No first order autocorrelation												
F(1,24)	12,046	F(1,45)	21,417	F(1,70)	23,007	F(1,24)	49,276	F(1,45)	39,355	F(1,70)	78,444	
Pr> F	0,0020	Pr> F	0,0000	Pr> F	0,0000	Pr> F	0,0000	Pr> F	0,0000	Pr> F	0,0000	
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity, Ho: Constant variance												
chi2(1)	263,18	chi2(1)	2,78	chi2(1)	1308,8	chi2(1)	137,84	chi2(1)	29,86	chi2(1)	321,89	
Pr> chi2	0,000	Pr> chi2	0,095	Pr> chi2	0,000	Pr> chi2	0,000	Pr> chi2	0,000	Pr> chi2	0,000	
Likelihood-ratio test, H0: Error term is homoscedastic												
LR chi2	425,12	LR chi2	339,56	LR chi2	1278,3	LR chi2	268,9	LR chi2	193,77	LR chi2	563,13	
Pr> chi2	0,000	Pr> chi2	0,0000	Pr> chi2	0,000	Pr> chi2	0,000	Pr> chi2	0,000	Pr> chi2	0,000	

Table 7: Model Specification Tests

---

[1]VIF: Variance Inflation Factors

Variable	Islamic banks		Conv. banks		All banks	
	Vif	1/Vif	Vif	1/Vif	Vif	1/Vif
RWCR	3,70	0,2699	1,19	0,8437	2,44	0,4106
NPLS	1,08	0,9288	1,03	0,9666	1,01	0,9937
LA	3,62	0,2765	1,18	0,8443	2,44	0,4106
Mean VIF	2,80		1,13		1,96	

Table 8: Multicollinearity Test (VIFs)

The validity of the panel GMM estimator depends on the quality of the selected instruments (Sargan test) as well as on zero autocorrelation of errors in the second-order difference equation (AR2). The results of Sargan test (1958)[2] ((Table 9) indicate that the null hypothesis of zero autocorrelation of instrumental variables with the error terms is maintained. Moreover, the values of the Arellano-Bond autocorrelation test (1991)[3] (Table 10) confirm the absence of second order error autocorrelation.

	Stochastic Frontier			Meta Frontier		
	Islamic banks	Conv. Banks	All banks	Islamic banks	Conv. banks	All banks
Chi2	20,1475	45,8323	56,129	18,605	43,174	37,751
Pr> Chi2	0,9988	0,3555	0,186	0,9996	0,4639	0,698

Table 9: Sargan Test of over Identifying Restrictions

	Stochastic Frontier						Meta Frontier					
	Islamic Banks		Conv. Banks		All banks		Islamic Banks		Conv. Banks		All banks	
Order	Z	Pr>Z	Z	Pr>Z	Z	Pr>Z	Z	Pr>Z	Z	Pr>Z	Z	Pr>Z
1	-2,505	0,012	-3,117	0,002	-3,217	0,001	-2,335	0,019	-3,290	0.001	-3,832	0,000
2	-0,107	0,915	1,269	0,204	-0,448	0,654	0,074	0,940	0,668	0,504	0,588	0,556

Table 10: Arellano-Bond Test for Zero Autocorrelation in First-Differenced Errors

Table 11 presents the results of six regressions. The first three regressions are related to cost-efficiency scores calculated on the basis of the stochastic frontier, while the last three are reserved to the cost-efficiency scores determined by the meta-frontier function.

	Stochastic Frontier			Meta Frontier		
	Islamic	Conventional	All	Islamic	Conventional	All
Eff(-1)	0,70652*	0,54682*	0,57945*	0,52741*	0,57283*	0,58583*
	(0,03071)	(0,00208)	(0,02343)	(0,04369)	(0,01081)	(0,03124)
RWCR	0,00099*	0,00010*	0,02343*	0,00197*	0,00158*	0,00159*
	(0,00012)	(0,00002)	(0,00012)	(0,00011)	(0,00012)	(0,00028)
NPLS	0,00071*	-0,00114*	-0,00012	0,00072*	0,00058*	0,00099*
	(0,00012)	(0,00004)	(0,00011)	(0,00009)	(0,00008)	(0,00012)
LA	-0,00062*	-0,00035*	-0,00032*	-0,00122*	-0,00085*	-0,00095*
	(0,00004)	(0,00001)	(0,00006)	(0,00009)	(0,00005)	(0,00013)
Cons	0,24320*	0,44650*	0,38134*	0,34961*	0,33162*	0,31575*
	(0,02580)	(0,00211)	(0,02196)	(0,03196)	(0,01101)	(0,02444)
Wald chi2(4)	9123,23	258643,79	2882,86	18363,75	76292,69	1037,30
Prob> chi2(4)	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
N. obs	162	383	545	162	383	545

Table 11: Estimation Regressions
(*) Translated a Significance of 1%

The six regressions reveal a positive and statistically significant effect of the delayed efficiency variable, which implies that the improvement of cost efficiency remains one of the main concerns of banking institutions.
The results of the first two regressions show that the cost-efficiency variation of Islamic and conventional banks,as a result of a variation in credit risk,is not the same. In fact, increase in credit risk entails a decrease in efficiency of conventional banks, and an increase in that of Islamic banks (rejection of hypothesis H2). These results coincide with those of Alam

---

[2] Sargan,J.: "The Estimation of Economic Relationships Using Instrumental Variables", Econometrica, vol. 26, 1958, p. 393-415
[3] *Arellano*, M., & *Bond*, S. (*1991*): "*Some tests of specification for panel data*: Monte Carlo evidence and an application to employment equations", The review of economic studies, 58 (2), 277-297

(2012), and allow the detection of a significant difference between the two categories of banks in terms of the relationship between cost efficiency and credit risk. Meta-frontier analysis shows different results. In fact, the efficiency of the twotypes of bank increases as a result ofan increase in credit risk (acceptance of H2). The explanation of the nature of this relationship can be found inHughes et al., (1997)who suggest that under thehypothesis of risk aversion, bank managers are willing to forego a portion of their remuneration as a result of a risk increase. This result is consistent with those found in studies byMiller andNoulas (1997), Gorton and Rosen (1995),Altunbas et al., (2007), Yener et al. (2007), Yong and Christos (2013), Saeed andIzzeldin (2014), Rosman et al. (2014) and GhroubiandAbaoub (2016b).

Moreover, the results of all regressions indicate a positive and statistically significant relationship between the regulatory capital and cost efficiency. This result is consistent with that of Kwan and Eisenbeis (1997)who make it clear that the best-managed banks have a higher capacity to achieve capital accumulation. The same result is also arrived at in Pessarossi and Weill (2015) and Ben Mbarek et al., (2015). The negative and statistically significant sign of the LAR variable implies that any increase in liquidity ratio causes a decrease in cost efficiency. Thus, banks in the GCC countries possess excessive liquidity, which, although it bolsters their financial stability, reduces their efficiency. This result is also arrived at in the work of Louati (2016) who finds a positive relationship between liquidity ratio, measured by the ratio of total credit and total assets, and technical efficiency.

5. Conclusion

This paper aims at studying the relationship between cost efficiency and credit risk in a dual banking system in the GCC region during 2006-2015. Two stages are therefore set up; the first stage involves the calculation of cost efficiency scores by using the stochastic frontier method and the meta-frontier analysis; the second involves the study of the relationship between efficiency and risk using the GMM model. Results of the first stage show that the average of cost-efficiency scores of Islamic banks is lower than that of conventional banks. According to the meta-frontier analysis, this difference is attributable to the lack of managerial competence of Islamic banks. The result of this analysis confirms that the two types of bank have the same modus operandi.

In the second stage, the descriptive study shows that Islamic banks are more exposed to credit risk, measured by the ratio of non-performing loans (NPLS), yet they possess higher levels of liquidity and regulatory capitals than conventional banks. Estimation of the determinants of cost efficiency, calculated by the stochastic frontier, has shown that the cost-efficiency variation, which is due to variation in credit risk, of Islamic banks and that of conventional banks are not the same. These variations have become identical with reference to the meta frontier of the efficiency scores.

Moreover, the introduction of the liquidity variable and regulatory capital variable proves that an increase in liquidity is followed by degraded cost efficiency, while the effect of regulatory capital is positive and statistically significant.

6. References

i. Abdul-Majid, M., Saal, D., S. and Battisti, G. (2008), "The efficiency and productivity of Malaysian banks: an output distance function approach". Aston Business School Research Paper R, P0815.

ii. Abdul-Majid, M., Saal, D., S. and Battisti, G. (2010), "Efficiency in Islamic and conventional banking: An international comparison". Journal of Productivity Analysis, 34(1), 25–43.

iii. Abdul-Majid, M., Saal, D., S. and Battisti, G. (2011a), "Efficiency and total factor productivity change of Malaysian commercial banks". Service Industries Journal 31(13), 2117–2143.

iv. Abdul-Majid, M., Saal, D., S. and Battisti, G.(2011b), "The impact of Islamic banking on the cost efficiency and productivity change of Malaysian commercial banks". Applied Economics 43(16): 2033-3054.

v. Aigner, D., J., Lovell, C., A., K., and Schmidt, P. (1977), "Formulation and estimation of stochastic frontier production function models", Journal of Econometrics 6 (1), 21–37.

vi. Alam, N. (2012), "Efficiency and risk-taking in dual banking system: Evidence from emerging markets". International Review of Business Research Papers, 8(4), 94–111.

vii. Altunbas, Y., Carbo, S., Gardener, E., P., M., and Molyneux, P. (2007), "Examining the relationships between capital, risk and efficiency in European banking". European Financial Management 13, 49–70.

viii. Altunbas, Y., Liu, M-H., Molyneux, P. and Seth, R., (2000). "Efficiency and risk in Japanese Banking". Journal of Banking and Finance 24, 1605-1628.

ix. Arellano, M. and Bond, S. (1991), "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations". Review of Economic Studies, 58, 277–297.

x. Arellano, M. and Bover, O. (1995), "Another look at the instrumental variable estimation of error-components models", Journal of Econometrics 68(1), 29-51.

xi. Battese, G., E., D., S., P., Rao, and C., J., O'Donnell (2004), "A Metafrontier Production Function for Estimation of Technical Efficiencies and Technology Gaps for Firms Operating Under Different Technologies". Journal of Productivity Analysis, 21, 91-103.

xii. Battese. G. E and T. J. Coelli. (1995), "A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data". Empirical Economics 20,325-332

xiii. Beck, T., Demirgüç-Kunt, A. and Merrouche, O. (2013), "Islamic vs. Conventional Banking Business Model, Efficiency and Stability". Journal of Banking and Finance 37, 433–447.

xiv. Ben Mbarek H., Ben Mbarek K. and Khemiri S., (2015), "Regulation, Market Structure, Risk and Bank Profitability in the Emerging Countries during the Subprime Crisis". Journal of Finance and Economics, 3, (1), pp15-19. http://pubs.sciepub.com/jfe/3/1/3

xv.   Berger, A. and DeYoung, R. (1997), "Problem loans and cost efficiency in commercial banking". Journal of Banking and Finance 21, 849-870.

xvi.   Berger, A., N., and Mester, L. (1997), "Inside the black box: what explains differences in the efficiencies of financial institutions?"Journal of Banking and Finance, 21, 895-947.

xvii.   Blundell, R., and Bond, S. (1998). "Initial conditions and moment restrictions in dynamic panel data models". Journal of Econometrics, 87, 115–143.

xviii. Carvallo, O.and Kasman, A. (2005), "Cost efficiency in the Latin American and Caribbean banking systems". International Financial Markets, Institutions and Money 15,55–72

xix.   Chapra, U. (2008), "The Global Financial Crisis and the Islamic Financial System". Paper presented at the Forum on The Global Financial Crisis, Islamic Development Bank.

xx.   Deelchand, T. and Padget, C. (2009), "The Relationship between Risk, Capital and Efficiency: Evidence from Japanese Cooperative Banks". ICMA Discussion Paper in Finance, DP 2009–12.

xxi.   Malikov, E., Tobón, D.R, and Kumbhakar, S.C (2014), "Estimation of banking technology under credit uncertainty". Springer-Verlag Berlin Heidelberg. DOI 10.1007/s00181-014-0849-z

xxii.   Farooq, M. and Zaheer.S. (2015), "Are Islamic banks more resilient during financial panics?", Pacific Economic Review, 20(1), 101–124.

xxiii. Fiordelisi, F., Marques-Ibanez, D. and Molyneux, P. (2011), "Efficiency and risk in European banking". Journal of Banking and Finance 35, 1315–1326.

xxiv.   Ftiti, Z., Nafti, O. and Srairi, S. (2013), "Efficiency of Islamic banks during subprime crisis: Evidence of GCC countries", The Journal of Applied Business Research, 29(1), 285–304.

xxv.   Ghroubi, M. and Abaoub, E. (2016a), "A Meta-Frontier Function for the Estimation of Islamic and Conventional Banks'Cost and Revenue Efficiency: The Case of Malaysia from 2006 to 2012", International Journal of Business and Management. 11(5), 254-270. http://dx.doi.org/10.5539/ijbm.v11n5p254

xxvi.   Ghroubi.M. and Abaoub.E. (2016b), "A Study of the Determinants of Cost and Revenue Efficiency in the Context of Islamic and Conventional Banks: The Case of Malaysia from 2006 to 2012", International Journal of Economics and Finance, 8(7), 258 274.http://dx.doi.org/10.5539/ijef.v8n7p258

xxvii. Gorton, G. and Rosen, R. (1995), "Corporate control, portfolio choice and the decline of banking", Journal of Finance, Vol. 50 (5), pp.1377-1420.

xxviii. Hasan, M. and Dridi, J. (2010), "The Effects of the Global Crisis on Islamic and Conventional Banks: A Comparative Study", IMF Working Paper # WP/10/201.

xxix.   Hassan, I., and Merton, K., (2003), "Development and efficiency of the banking sector in a transitional economy: Hungarian banking experience", Journal of Banking and Finance 27, 2249-2271.

xxx.   Hassan, T., Mohamad, S. and Bader,M. K. I (2009), "Efficiency of conventional versus Islamic banks: evidence from the Middle East". International Journal of Islamic and Middle Eastern Finance and Management 2(1): 46-65.

xxxi.   Huang T., H., Chiang L., C. and Chen K., C. (2011), "An Empirical Study of Bank Efficiencies and Technology Gaps in European Banking", The Manchester School, 79 (4), 839-860.

xxxii. Hughes JP and Mester L.J. (1998), "Bank capitalization and cost: evidence of scale economies in risk management and signaling", Rev Econ Stat 80(2):314–325

xxxiii. Hughes, JPand Mester. L (2013), "Who said large banks don't experience scale economies? Evidence from a risk-return-driven cost function", Journal of Financial Intermediation 22 (4), 559–585.

xxxiv. Hughes, J., L. Mester, and C. Moon. (2001), "Are scale economies in banking elusive or illusive? Evidence obtained by incorporating capital structure and risk-taking into models of bank production", Journal of Banking and Finance 25 (12), 2169–2208.

xxxv.   Hughes, J., P., Lang, W., Mester, L., J., and Moon, C., G. (1994), "Recovering Technologies That Account for Generalized Managerial Preferences: An Application to Non-Risk-Neutral Banks", Department of Economics, Rutgers University.

xxxvi. Hughes, J.P and Mester, L.J. (1993), "A quality and risk-adjusted cost function for banks: Evidence on the 'too-big-to-fall' doctrine", Journal of Productivity Analysis 4, 293-315.

xxxvii. Hughes, J.P., Mester, L.J. and Moon, G.J. (2000), "Are all scale economies in banking elusive or illusive: evidence obtained by incorporating capital structure and risk taking into models of bank production", Center for Financial Institutions Working Papers 00-33, Wharton School Center for Financial Institutions, University of Pennsylvania

xxxviii. Hussain, H., and Al-Ajmi, J. (2012), "Risk management practices of conventional and Islamic banks In Bahrain",Journal of Risk Finance (Emerald Group Publishing Limited), 13(3), 215 239.

xxxix. Isik, I., and Hassan, M., K. (2002), "Technical, scale and allocative efficiencies of Turkish banking industry", Journal of Banking and Finance 26, 719-766.

xl.   Johnes, J., Izzeldin, M. and Pappas, V. (2013), "A comparison of performance of Islamic and conventional banks 2004 to 2009". Journal of Economic Behavior and Organization.http://dx.doi.org/10.2139/ssrn.2071615

xli.   Johnes, J., M. Izzeldin and V. Pappas (2009), "The efficiency of Islamic and conventional banks in the Gulf Cooperation Council (GCC) countries: An analysis using financial ratios and data envelopment analysis", LUMS Working Papers Series 2009/023 Lancaster University Management School.

xlii.   Kabir, N., Worthington, A., C., and Gupta, R. (2015), "Comparative credit risk in Islamic and conventional banks", Pacific-Basin Finance Journal.doi: 10.1016/j.pacfin.2015.06.001

xliii. Kasman, A., and Yildirim, C. (2006), "Cost and profit efficiencies in transition banking: the case of new EU members", Applied Economics 38, 1079-1090.

xliv.   Khediri, K., Charfeddine, L. and Ben Youssef, S. (2015), "Islamic versus conventional banks in the GCC countries: a comparative study using classification techniques", Journal of Economic Behavior and Organization, 103, 39-55.

xlv.   Koetter, M. (2008), "The stability of efficiency rankings when risk-preferences and objectives are different", The European Journal of Finance 14 (2), 115–135.

xlvi.   Kwan, S.and Eisenbeis, R.A. (1997), "Bank risk, capitalization, and operating efficiency", Journal of Financial Services Research 12 (2–3), 117–131.

xlvii.   Louati, S. and Boujelbene,Y.(2015), "Banks' stability-efficiency within dual banking system: A stochastic frontier analysis" International Journal of Islamic and Middle Eastern Finance and Management, 8(4), 472–490.

xlviii.   Louati,S., Louhichi, A. and Boujelbene,Y.(2016), "Therisk-capital-efficiency trilogy:A comparative study between Islamic and conventional banks",Managerial Finance, 42(12), 1226–1252.

xlix.   Matthews, K., and Ismail, M. (2006): "Efficiency and productivity growth of domestic and foreign commercial banks in Malaysia", Cardiff Economics Working Papers E2006/2.

l.   Meeusen, W., and Broeck, J.v.d. (1977), "Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error", International Economic Review, 18 (2), 435-44.

li.   Mester, L. J. (1996), "A study of bank efficiency taking into account risk-preferences", Journal of Banking and Finance 20, 1025-1045.

lii.   Miah.M.D. and Uddin.H. (2017), "Efficiency and stability: A comparative study between Islamic and conventional banks in GCC countries",Future Business Journal 3,172–185 (http://creativecommons.org/licenses/by-nc-nd/4.0/)

liii.   Miller, S., M. and Noulas, A., G. (1996), "The technical efficiency of large bank production", Journal of banking and finance 200, 495-509.

liv.   Mohanty, S.K., Lin, H.-J., Aljuhani, E.A. and Bardesi, H.J. (2016), "Banking Efficiency in Gulf Cooperation Council (GCC) Countries: A Comparative Study", Review of Financial Economicsdoi: 10.1016/j.rfe.2016.06.004

lv.   Mokhtar, H., S., A., Abdullah, N., and Alhashi, S., M. (2008), "Efficiency and competition of Islamic banking in Malaysia", Humanomics 24(1), 28-48.

lvi.   Naama Trad, N. Trabelsi, M.A and Goux, J.F. (2017), "Risk and profitability of Islamic banks: ¿A religious deception or an alternative solution?",European Research on Management and Business Economics 23, 40–45

lvii.   Nguyen, TPT and Nghiem, SH. (2015), "The interrelationships among default risk, capital ratio and efficiency: evidence from Indian banks", Managerial Finance, vol. 41, no. 5, pp. 507-25.

lviii.   Pessarossi, P. and Weill, L (2015), "Do capital requirements affect cost efficiency? Evidence from China", Journal of Financial Stability.http://dx.doi.org/10.1016/j.jfs.2014.11.002

lix.   Podpiera, J. and Weill, L. (2008), "Bad luck or bad management? Emerging banking market experience",Journal of Financial Stability 4(2), 135-148.

lx.   Rosman, R., Abdul Wahab, N. and Zainol, Z. (2014), "efficiency of islamic banks during the financial crisis: An analysis of Middle Eastern Asian countries",Pacific-Basin Finance Journal, 28, 76–90.

lxi.   Saeed, M. and Izzeldin, M. (2014), "Examining the relationship between default risk and efficiency in Islamic and conventional banks", Journal of Economic Behavior and Organization.

lxii.   Sealey, C., W., and Lindley, J., T. (1977), "Inputs, Outputs and a Theory of Production and Cost Depository Financial Institutions",Journal of Finance, 32 (4), p 1251- 1266.

lxiii.   Shahid, H., R. Ur Rehman, G. S. K. Niazi and A. Raoof (2010), "Efficiencies comparison of Islamic and conventional banks of Pakistan",International Research Journal of Finance and Economics 49: 24-42.

lxiv.   Sun, L., and Chang, T. P. (2011), "A comprehensive analysis of the effects of risk measures on bank efficiency: Evidence from emerging Asian countries",Journal of Banking & Finance, 35(7), 1727-1735. dx.doi.org/10.1016/j.jbank_n.2010.11.01

lxv.   Tan, Y. (2016), "Investigating the performance of Chinese banks: efficiency and risk features", Palgrave Macmillan studies in banking and financial institutions.

lxvi.   Tan, Y., and Anchor, J. (2017), "The impacts of risk-taking behaviour and competition on technical efficiency: evidence from the Chinese banking industry", Research in International Business and Finance

lxvii.   Williams, J.(2004), "Determining management behaviour in European banking",Journal of Banking and Finance 28, 2427-2460.

lxviii.   Yener, A., Carbo, S., Gardener, E., and Molyneux, F. (2007), "Examining the Relationships between Capital, Risk and Efficiency in European Banking", European Financial Management, 13(1), 49–70.

lxix.   Yong, T. and Christos, F. (2013), "Risk, capital and efficiency in Chinese banking", Int. Fin. Markets, Inst. AndMoney 26, 378– 393.

Appendix

	Cost efficiency			
	Islamic	**Conventional**	**Commun**	**Meta-frontier**
α_1	0,2074328	0,2491479***	0,2939664*	0,507418526*
	(0,1857213)	(0,145408)	(0,1076626)	(1,,00E-12)
α_2	-0,1711051	0,8907771*	-0,1813694**	0,219520874*
	(0,1579468)	(0,0847516)	(0,0834544)	(0,10E-11)
α_3	0,0400765	0,9658223*	-0,6102849*	-0,573448118 *
	(0,3949498)	(0,1871464)	(0,1889695)	(1,80E-12)
β_1	0,6278326	0,0691921	0,4432009*	1,115506589*
	(0,2024338)	(0,1502604)	(0,0906728)	(6,60E-12)
β_2	0,3411331	0,2893919*	0,2074225***	-0,852817666 *
	(0,2306177)	(0,1010291)	(0,1171438)	(3,50E-12)
α_{11}	0,0197401	-0,0786961**	0,0549276**	0,055353093*
	(0,047307)	(0,0331697)	(0,027882)	(1,20E-13)
α_{12}	0,0567593	-0,097303*	-0,0469875	-0,15604076*
	(0,062879)	(0,0268058)	(0,0308403)	(2,40E-12)
α_{13}	0,0911488	0,148569**	0,1551195*	0,057165879*
	(0,0909163)	(0,0685025)	(0,0535084)	(4,40E-13)
α_{22}	0,0449103	0,4606096*	0,1329833*	-0,035451089*
	(0,0447483)	(0,0141187)	(0,026507)	(2,25E-12)
α_{23}	-0,1476783	-0,1328972*	-0,2351829*	-0,050975993*
	(0,1094933)	(0,032033)	(0,0518207)	(3,20E-12)
α_{33}	-0,0473914	-0,3064478*	-0,6350832*	-0,891041559*
	(0,2728833)	(0,0333418)	(0,0503513)	(0,90E-12)
β_{11}	0,3342899*	0,2406358*	0,3573681*	0,007789044*
	(0,0334309)	(0,0432325)	(.0183827)	(1,20E-12)
β_{12}	-0,2702198*	-0,2293116*	-0,2623579*	-0,175039155*
	(0,0438583)	(0,028207)	(0,0222662)	(2,55E-12)
β_{22}	0,309843*	0,2071917*	0,2020908*	0,438866152*
	(0,0513297)	(0,0202292)	(0,0244322)	(7,32E-13)
δ_{11}	-0,0301534	-0,0587541***	-0,0137417	-0,252177129*
	(0,0359023)	(0,0350911)	(0,0211083)	(9,20E-13)
δ_{12}	0,0437388	0,0401577***	-0,0013483	0,003088159*
	(0,0583607)	(0,0230703)	(0,0191396)	(1,09E-13)
δ_{21}	0,0436926	0,0358832	0,1244649*	0,014360042*
	(0,0446452)	(0,0232776)	(0,023019)	(2,35E-12)
δ_{22}	0,0188426	0,0030652	-0,0519095**	-0,064494272*
	(0,0564773)	(0,0171102)	(0,0252388)	(4,36E-12)
δ_{31}	0,1245487	-0,291608*	-0,0207078	0,065073504*
	(0,1013619)	(0,0639456)	(0,0493699)	(1.26E-12)
δ_{32}	-0,021553	-0,062547	-0,129174**	-0,259326839*
	(0,1192882)	(0,0453985)	(0,0562108)	(1,02E-12)
β_0	-0,3080856	2,72942*	-0,46371***	0,137545373*
	(0,4387302)	(0,3504609)	(0,2511162)	(6,30E-11)
Mu Cons	-322,6644	-59,3573	-184,5461	
	(251,2139)	(327,1167)	(129,5703)	
Usigma cons	4,314819*	0,9197445	3,2109*	
	(0,7798984)	(5,500911)	(0,7013494)	
Vsigma cons	-5,127044*	-7,776694*	-5,502823*	
	(0,2182343)	(0,1894377)	(0,1008049)	
sigma_u	8,648703*	1,583872	4,980101*	
	(3,372555)	(4,356369)	(1,746395)	
sigma_v	0,077033*	0,0204792*	0,0638377*	
	(0,0084056)	(0,0019398)	(0,0032176)	
Lambda	112,2728*	77,34062*	78,01193*	
	(3,372782)	(4,356335)	(1,746434)	
Log likelihood	52,8822	772,2035	442,8931	
Wald chi2	4627,55	70608,49	19179,07	
P>chi2	0,0000	0,0000	0,0000	

Table 12: AI. Parameters Estimation of Various Frontiers of Cost Efficiency