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Investigating efficiency of GCC banks: a non-parametric approach

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Investigating Efficiency of GCC Banks: A Non-Parametric Approach

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ABSTRACT

The aim of this paper is to measure Gulf Cooperation Council (GCC) banks efficiency. Data envelopment analysis (DEA) is performed to assess the technical efficiency of the top 50 GCC banks as a homogenous set over the period 2005-2008. Cross-sectional data for each year is used in the analysis to determine those banks operating on the efficiency frontiers which are used as benchmarks for their peer banks. The sensitivity of the results is investigated by applying constant return to scale (CRS), variable return to scale (VRS) DEA models. Data on banks based on two-year period windows each and covering the overall time period 2005-2008 are incorporated into DEA analysis providing us with targets for improvement over time.

The results show that only 14 banks of the sample are rated as efficient under CRS and/or VRS assumptions, and indicate that Islamic banks perform slightly better than the other types of banks.

INTRODUCTION

We have investigated whether or not there are efficiency differentials between Islamic banks and conventional banks. Such investigation is motivated by the assumption that Islamic banks should be more efficient. DEA was introduced by Charnes *et al.* (1978) and it is recognized as a benchmarking technique for efficiency measurement and evaluating the performance of organizations involved in a wide range of contexts: banking (Avkiran 2009), hospitals (Banker, 1984), airports (Lam 2009), tourist hotels (Yu, 2009), educational institutions (Carrico *et al.* 1997; Celik *et al.* 2009), electricity sector (Hrovatin, 2009), transportation and construction contractors (El-Mashaleh, 2009). The firms range from public to private and non profit organizations. It is widely used by researchers to help managers, economists, chief executives, principals, unit leaders and firms' policy makers to make critical decisions. Wu *et al.* (2009) used DEA to assess the performance of Olympic games. DEA may be applied to a single organization with multiple units as it may be applied across organizations operating under similar technologies. Edirisinghe *et al.* (2008) reported the use of DEA in a case study of 313 US unalike industry firms but grouped into 6 alike technological activities. DEA may be used from small-scale of less than 20 units to large-scale implementation involving more than 1000 organizational units (Medina-Borja, 2007). DEA was successfully used to assess new information tools introduced in firms such as Enterprise Resource Planning, (Bendolly, 2009). Wang (2007) proposed models using DEA for preferential voting system.

Inventive in-depth description of DEA can be found in the well known papers of Charnes *et al.* (1978) and Banker *et al.* (1984). Three useful papers by Adler (2008), Wade (2009) and by Bougnol (2010) may be reviewed for experimenting with DEA.

DEA determines a single score characterizing each firm as a consequence of transforming input to output. A firm input may be employee salaries, cost of borrowing money, operating cost (eg. call centers, number of ATM machines) and level of computerization, providing the various financial instruments. DEA analyses the performance based on the output generated from the consumed input while carrying various operations. Firms output may be employees' job satisfaction, customer services, number of transaction, net profits...

Though DEA is used extensively in financial related applications, however, only a limited work is published on The Gulf Cooperation Council (GCC) banking.

Our paper exploits the provided GCC panel data over a four year period (2005-2008) to investigate the performance of the GCC banking institutions. Such research output would help banks to acquire knowledge about the competitiveness from similar banks working under the same political, economical and geographical environment.

The remainder of the paper is organized as follows. Section 1 reviews the relevant literature. Section 2 describes the data sources and model specification. Empirical results are presented in section 3. Finally, section 4 concludes the study.

LITERATURE REVIEW

In our study, DEA is used to obtain a measurement of performance of the GCC's top 44 banks. Some of these are Islamic banks which are essentially riba-free ("riba" is usually translated simply as "usury"). Islamic banks adopt various financial instruments in operating their businesses (e.g. Trustee Finance Contract (*Mudāraba*), Safekeeping (*Wadiah*), Equity Participation Contract *(Mushāraka)*, Cost plus (*Murabahah*), Islamic Bonds *(Musaka)* and leasing (*Ijarah*)).

The other banks are known as conventional with an Islamic windowing; that is providing services to Muslims engaging in Islamic law (*Sharia*). In fact, the past two decades have witnessed a substantial increase in the number of Islamic banks, financial institutions and Islamic funds in different parts of the world. It was to meet this demand and capture this emerging market that the conventional banks started opening Islamic windows and Islamic units for those clients who do not want to indulge in interest-based transactions. This conviction created an increased demand for Islamic products in the field of financing, and gave birth to a market where only Islamic products are acceptable. Thus, banks working under Islamic windows are established to provide an additional service to Muslim clients or to offer a variety of products for general clientele. The remaining banks are referred in our article as Conventional banks.

The choice of the GCC countries is influenced by the fact that these countries operate under similar economic and political conditions. Only a limited work has been done on GCC banks; most related work has been reviewed as presented in **Table 1** (see the Appendix) which provides a listing of inputs and outputs chosen for studies on GCC banks performance analysis.

METHODOLOGY: DEA APPROACH

DEA is a tool for efficiency measurements by assigning a single measure of efficiency falling in the range (0-1) for each decision-making unit (DMU) in relation to others relative to its peers. It enables units to be compared to other units in terms of efficiency. A DMU is considered efficient if it has an efficient score of 1.0. Efficient DMUs form together a surface frontier where all the inefficient units lie. Such measures uncover efficient firms from inefficient ones.

DEA in its standard form does not provide sufficient discrimination between the efficiency of DMUs especially for small samples. In particular, for efficient units, there is no mechanism to differentiate between them. Further, standard DEA fell short from identifying sources of inefficiencies.

Such limitations leaded to new DEA approaches such as incorporating cross-evaluation techniques (Bao *et al*. 2008) and by the use of weight restrictions (Thanassoulis, 2001) and by incorporating simultaneous changes to the inputs and outputs that are technologically similar (Podinovsky, 2007).

Sowlati (2004) proposed a new mathematical model yielding a new frontier so that the efficient units may be compared among themselves. A general model framework for DEA including the standard DEA is described in Klein (2004). Recent publications by Avkiran (2009) proposed an extension to standard DEA known as network DEA for identifying sources of inefficiencies. Such an extension requires access to underlying diagnostic information which is inaccessible to outside researchers. A recent complementary method to DEA proposed by Madlener (2009) attempt to assign each DMU to an ordered category. Galadera (2003) investigated the DEA model specification. Using Cobb-Douglass production function relating output to input, the author simulated the effect of omission of relevant variables and inclusion of irrelevant variables on the measured efficiencies. An excellent discussion of the DEA potentials when combined to other methodologies can be found in the paper by Avkiran (2009). In this framework, Po (2009) utilized statistical multivariate analysis to establish a DEA-based clustering technique of the DMUs. Unlike in regression, DEA does not provide a confidence interval of the measured efficiencies. Ruggiero (2004) considered the effect of stochastic data on efficiency measurement. Both positive features and limitations are presented in **Table 2**.

Table 2. DEA advantages and limitations

Powerful features	Limitations
1. Capacity to incorporate multiple inputs and outputs	Data integrity: assumes that data is free of measurement errors
2. Does not impose a parametric approach so no priory assumption on the distribution of inputs and outputs	Sensitive to unreliable and outlier data
3. No need to assign weights to inputs and outputs	DMUs are efficient in relation to others in the sample
4. Measurement units of inputs and outputs need not to be congruent (persons, areas, money,	Very sensitive to model misspecification (omitting or adding variables)
5. Derivation of target values for improving inefficient DMUs .	Necessary to use convenient inputs and outputs to avoid misleading results.

Two DEA models are generally applied: Constant Return to Scale (CRS) model named CCR as proposed by Charnes, Cooper, and Rhodes (1978), it is assumed that a DMU modifies its scale by increasing or decreasing both inputs and outputs in the same proportions; and the Variable Return to Scale (VRS) model named BCC as proposed by named after Banker, Charnes and Cooper (1984) relates well to the risk since in principle as the risk increases (input), returns increases but at diminishing rate. Inefficient firms, in principle could reduce their input (total assets) as a controllable parameter while maintaining the specified level of output. Inefficient firms may also strive for a higher output with the same level of input.

The CCR efficiency is formulated as linear programming model:
For each DMU = k = 1...J
Min θ_k
Subject

$$z_1.X_{1,1} + z_2.X_{2,1} + \ldots + z_J.X_{J,1} \leq \theta_k \,.\, X_{k,1}$$
$$z_1.X_{1,2} + z_2.X_{2,2} + \ldots + z_J.X_{J,2} \leq \theta_k \,.\, X_{k,2}$$
$$\ldots$$
$$z_1.X_{1,N} + z_2.X_{2,N} + \ldots + z_J.X_{J,N} \leq \theta_k \,.\, X_{k,N}$$

(N is the number of inputs)

$$z_1.Y_{1,1} + z_2.Y_{2,1} + \ldots + z_J.Y_{J,1} \geq Y_{k,1}$$
$$z_1.Y_{1,2} + z_2.X_{2,2} + \ldots + z_J.Y_{J,2} \geq Y_{k,2}$$
$$\ldots$$
$$z_1.Y_{1,M} + z_2.Y_{2,M} + \ldots + z_J.Y_{J,M} \geq Y_{k,M}$$
$$z_j \geq 0 \quad (j=1,..,J)$$

(M is the number of outputs)

In the above linear programming model, $X_{k,i}$ and $Y_{k,j}$ are respectively inputs and outputs of the k_{th} DMU. θ_k is the proportional reduction in inputs of the k_{th} DMU which are necessary to meet the specified output thus representing the efficiency of k_{th} DMU_k ($Bank_k$), z_k give the optimal weight associated with each input and output of the k_{th} DMU.

The BCC based on the variable return to scale model is formulated the same way as in the CCR model with an additional constraint: $z_1 + z_1 + \ldots z_J = 1$

This constraint would tolerate some of the slack variables associated with the above linear programming problem to be non zeros. Generally, the CCR efficiency does not exceed BCC efficiency (Cooper *et al.* 2007).

The Solver add-in that comes with Microsoft Excel may be applied to solve the above DEA problem for a given DMU. However it is very time consuming to solve repetitively the problem for each unit. Medinat (2007), in his work, used Excel solver combined with Visual Basic to run DEA. Instead we have used the free available internet software (http://nb.vse.cz/~jablon/dea.htm). As illustrated by the main software window interface, any of the 4 frontier types provided by the software could have been used. But we have chosen CRS and VRS for analysis. A purchased license for DEA-Solver-PRO may be found at (http://www.saitech-inc.com).

Data, inputs and outputs

The primary source of data for our study is Gulf Business Magazine. This magazine publishes annually a list of the top 50 GCC banks. The initial sample considered contains 50 banks for which a data was collected for the period 2005-2008. Six banks were excluded from analysis due to unavailable financial information which constrained us to restrict the sample to a total of 44 banks operating in 6 different GCC countries. Among these banks, one bank has changed its name from Kuwait Real Estate Bank to Kuwait International Bank and 2 banks went through Merger during 2007 (Emirates Bank International and National bank of Dubai became Emirates NBD). In this study, they are treated as different banks. Among our sample, 8 banks are Islamic banks, 20 banks with Islamic windows and 16 are conventional banks. UAE banks dominate the top 44 banks (12 banks). The banks' financial statements of total assets, equities and total incomes covering the period 2005-2008 are used to measure banks performance. Total assets and equities as inputs and total income as a single output are used in the DEA analysis as illustrated by **Figure 2**.

Figure 2: DEA Set up

Since DEA is limited to cross-sectional data representing the same time period, we have employed Dynamic DEA as described in Cullinane *et al.* (2005) to compare the firms' performance with other over different time periods. DEA permits to categorize the banks into two exclusive sets independently of their scale size: managerial efficient and managerial inefficient banks. In principle inefficient units can produce the same output with less input. Input orientation has been used in this study to analyze the DEA model. Further, dynamic DEA permits us to uncover and report any possible trend in bank efficiency over the period of 2005-2008.

Two inputs are considered for this analysis, namely: *Total assets and Total equity.* The output considered for the analysis is *Income* (Net profit). However, since the inputs are closely linked, a Principal Component Approach is used as done by Shanmugam and Johnson (2007).

Data Reduction: Principal Components

Moderate correlation between input variables should be desired. When input variables are uncorrelated, a dramatic reduction in DEA performance is reported by Galagedera (2003). However, Shanmugam and Johnson (2007) suggested that when variables are highly correlated, only one of those variables should be kept in the model. Our data set consists of a very high correlation between total assets and total equities. Hence, Principal Component (PC) is applied as a data reduction method to transform these highly correlated two inputs into one single PC variable. The PC vector is computed as an optimal combination of input variables using:

$$PC_{i,year} = a * Assets_{i,year} + a * Equity_{i,year}$$

Where the subscript i refers to the i_{th} DMU and the weight "a" is determined for each year by applying PC analysis in SPSS. DEA is then applied on the obtained PC as input and total income as output. CCR and BCC efficiency measurements based on using only the PC as an input are found to be strongly correlated to those determined previously.

Table 3: Pearson Correlation of the GCC financial data 2005-2008

Pearson Correlations												
Year	2005			2006			2007			2008		
Variables	Asset	Equity	Income	Asset	Equity	Income	Asset	Equity	Income	Asset	Equity	Income
I_Asset_2005	1											
I_Equity_2005	.918**	1										
O_Income_2005	.891**	.908**	1									
I_Asset_2006	.978**	.906**	.865**	1								
I_Equity_2006	.901**	.949**	.938**	.902**	1							
O_Income_2006	.824**	.847**	.926**	.806**	.933**	1						
I_asset_2007	.807**	.753**	.692**	.869**	.728**	.619**	1					
I_Equity_2007	.808**	.831**	.792**	.859**	.847**	.747**	.940**	1				
O_Income_2007	.657**	.738**	.833**	.696**	.825**	.830**	.705**	.854**	1			
I_Asset_2008	.788**	.751**	.718**	.854**	.735**	.636**	.983**	.937**	.751**	1		
I_Equity_2008	.784**	.816**	.807**	.836**	.844**	.759**	.890**	.949**	.866**	.928**	1	
O_Income_2008	.436**	.451**	.611**	.464**	.547**	.558**	.503**	.605**	.703**	.601**	.752**	1

Pearson correlation (Input/Output/Scores) reveals very high correlations between the three variables as presented in **Table 3.** It is expected to have a strong correlation to some extent between input and output. However, the portion of input (e.g. cost) invested in using new technologies, acquisition of new software and computerization may not necessarily be converted into outputs in the short run. Such technological investments, while considered as positive in the log run, put a limitation on the accuracy measured performance. According to Fernadez (2009), firms decide on the level of investment depending on the estimation of the risks and potential yields. However, in this research, it is assumed that all banks invest equally in proportions on new technologies.

RESULTS AND ANALYSIS

Both CCR and VRS were performed where DMUs with negative input and/or output values for 2007 and 2008 were eliminated during CCR analysis. VCR analysis does not require the elimination of those DMUs with negative inputs and/or outputs. The ratio of CRS scores to VRS scores provides a scale efficiency measurement. The efficient banks are listed in **Table 4**.

Table 4: GCC Efficient banks as measured by CRS and VRS DEA Analysis

Bank									
		CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS
National Commercial Bank	IS.W		Yes						
Al Rajhi Banking and Investment Corporation	IS	Yes	Yes		Yes	Yes	Yes		Yes
Bank of Kuwait and the Middle East	C							yes	yes
Investcorp	C								yes
Doha Bank	IS.W						yes		
Bank of Bahrain and Kuwait	C								yes
National Bank of Bahrain	C								yes
Bank Al Jazira	IS				yes		yes		
Kuwait Real Estate Bank/Kuwait International Bank	IS								yes
National Bank of Oman	C						yes		
Qatar Islamic Bank	IS		yes				yes		
Sharjah Islamic Bank	IS				yes		yes		
Bank of Sharjah	C				yes		yes		
The International Banking Corporation	C	yes	yes	yes	yes	yes	yes		yes

It can be seen from **Table 4** that of the 44 banks in the data set, 14 banks are efficient (7 Conventional banks, 5 Islamic banks and 2 Islamic windows banks). Some banks are efficient during all the period of study (Al Rajhi Banking & Investment Corporation and The International Banking Corporation). Other banks are efficient for a specific year as indicated in **Table 4.**

ANOVA on measured efficiencies

We have performed Analysis of variance (Anova) on measured efficiencies where the bank's type (Islamic/Islamic windows/Conventional) was treated as a factor. The statistical significance levels are given in **Table 5** in the appendix. Aggregate efficiency means as measured as a function of banks type are plotted in **Figures 3** and **4**. The figures reveal that Islamic banks perform slightly better than the other types of banks.

Figure 3. CRS measured efficiencies by bank's type

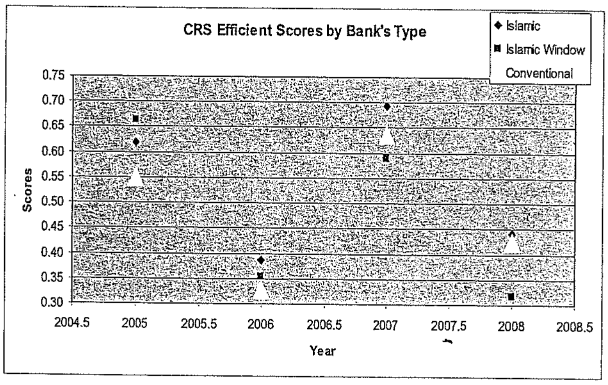
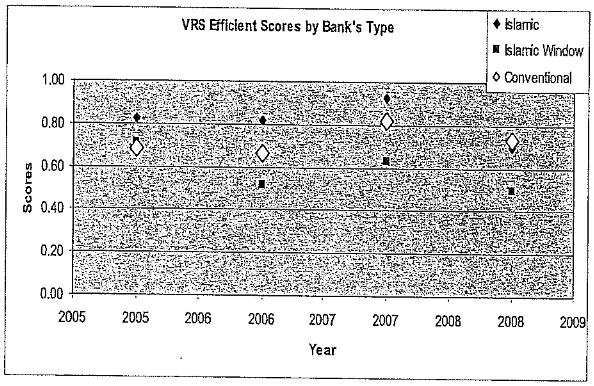


Figure 4. VRS measured efficiencies by bank's type



Window analysis: Efficiency change during the period 2005-2008

In order to assess the change of banks' performance during the period 2005-2008, we have applied window analysis over the period 2005-2008, (Cullinane, 2005). The basic idea of this technique is to regard each of the DMU as if it were a different DMU in each of the year included in the analysis. As an example for the window 2005-2008, the set consists of 2x44 = 88 DMUs and for the full window 2005-2008, the set consists of 4x44=176 DMUs. As illustrated by

Figure 5, the full window analysis reveals the existence of a significant difference (sig=0.001) in the relative efficiency means by banks' period. However as illustrated by **Figure 6**, the analysis reveals only moderate significance difference (sig=0.025) in the relative efficiency means by banks' type. Analysis of the smaller windows reveals similar results.

Figure 5. Relative efficiency means by year.

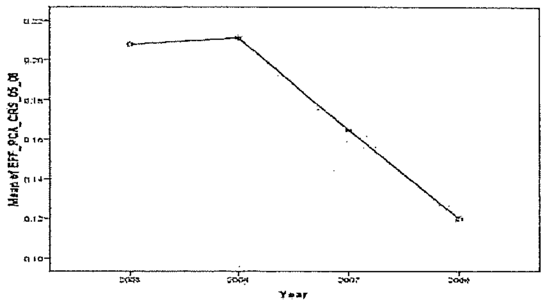
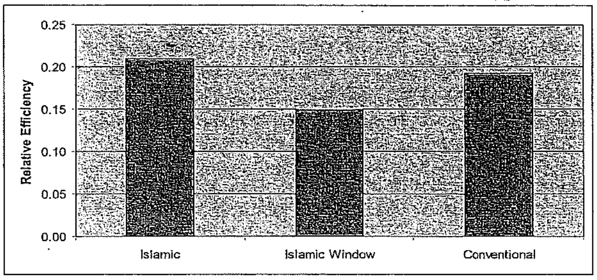


Figure 6. Relative efficiency means by bank's type



CONCLUSION

This study highlights increased efficiency throughout the GCC banking system. Specific efficiency gains from decreasing certain inputs (expenses) without a change in outputs (bank goals) for each inefficient bank are reported. Based on the findings, the subset representing those banks applying Islamic financial principles is compared with the other conventional banks. We hope that our implementation study will pass not only to academic researchers but to also decision makers in particular interested in the performance of GCC banking. A global information system within the GCC banks is needed to better evaluate the banks performance and to detect sources of inefficiencies. Our sample of 44 DMUs is relatively important and establishes a starting database for GCC countries. Our results represent a first attempt to establish a strong correlation between performance and banks type.

REFERENCES

Adler N. and A. Raveh, "Presenting DEA graphically", Omega 36, 715-729, (2008).

Al-Faraj T., A. Alidi and K. Bu-Bshait, "Evaluation of bank branches by means of data envelopment analysis", International Journal of Operations and Production Management, 13, 45-52 (1993).

Al-Tamimi, H.A.H., and A.M. Lootah, "Evaluating the operational and profitability efficiency of a UAE-based Commercial Bank", Journal of Financial Services Marketing 11 (4), 333–348, (2007).

Avkiran NK. "Opening the black box of efficiency analysis: An illustration with UAE banks", Omega 37,930-941, (2009).

Banker D., Charnes A, Cooper WW ,"Some models for estimating technical and scale inefficiencies in data envelopment analysis", Management Science 30, 1078-92, (1984).

Banker D., "Estimating most productive scale size using DEA", European Journal of Operational Research, 17, 35-44, (1984).

Bao C-P., T-H. Chen and S-Y. Chang, "Slack-based ranking method: an interpretation to the cross-efficiency method in DEA", Journal of the Operational Research Society 59,860-862, (2008).

Berger A.N. and D.B. Humphrey, "Measurement and efficiency issues in commercial banking. In Output Measurement in the Service Sectors Ed", The University of Chicago Press 245-300, (1992).

Bougnol M-L, J.H. Dula, Lins Estillita and Da Silva Moriera, "Enhancing standard performance practices with DEA", Omega 38, 33-45, (2010).

Carrico CS, Hogan SM, Dyson RG and Athanassopoulos AD (1997), "Data envelopment analysis and university selection", Journal of Operational Research Society 48, 1163-1177, (1997).

Celik O. and E. Alaattin, "Efficiency in accounting education: evidence from Turkish universities", Critical Perspectives on Accounting 20, 614-634 (2009).

Charnes A., WW. Cooper and E. Rhodes, "Measuring efficiency of decision making units", European Journal of Operational Research 2:429-444, (1978).

Cooper W. W., M. Seiford and L. Tone Kaoru, "Data Envelpoment Analysis", 2nd edition, Springer Science (2007).

Cullinane K., P. Ji and T. Wang, "The relationship between privatization and DEA estimates of efficiency in the container port industry", Journal of Economics and Business 57, 433-462, (2005).

Darrat A.F., C. Topuz and T. Youzef, "Assessing Cost and Technical Efficiency of Banks in Kuwait", paper presented at the ERF's 8th Annual Conference in Cairo, ERF, Cairo, available at: www.erf.org.eg (accessed 2 November 2008), (2002).

Duarte F. and D. Sandulli, "Technical Efficiency and use of information and communication in Spanish firms", Telecommunications Policy 33, 348-359 (2009).

Edirisinghe NCP. and X. Zhang, "Portfolio selection Ander DEA-based relative financial strength indicators: case of US industries", Journal of the Operational Research Society 59, 842-856, (2008).

Grigorian D. and V. Manole, "A Cross--Country Nonparametric Analysis of Bahrain's Banking System", IMF Working Paper, WP/05/117, (2005).

Hrovatin N., R. Pittman and J. Zoric, "Organisation and reforms of the electricity sector in Slovenia", Utilities Policies, 134-143, (2009).

Klein A., "A general model framework for DEA", Omega 32, 17-23, (2004).

Lam W. Shao, Low M.W. Joyce and Tng C. Loon, "Operational efficiencies across Asia Pacific airports", Transportation Research , 45 654-665, (2009).

Limam I., "Measuring Technical Efficiency of Kuwait Banks", API-Working Paper Series 0101, Arab Planning Institute - Kuwait, Information Center, (2004).

Madlener R., Antunes C. and L. Dias, "Assessing the performance of biogas plants with multi-criteria and data envelopment analysis", European Journal of Operational Research 197 1084-1094, (2009).

Medinat-Borja A., K.S. Pasapathy and K. Triantis, "Large-sclae data envelopment analysis (DEA) implementation: a strategic performance management approach", Journal of the Operational Research Society 58, 1084-1098, (2007).
Mostafa M., "Modeling the Efficiency of GCC Banks: a Data Envelopment Analysis Approach", International Journal of Productivity and Performance Management 56 (7) 623-643, (2007).
Po R-W., "A new clustering approach using data envelopment analysis", European Journal of Operational Research 199, 276-284, (2009).
Podinovsky VV., "Improving data envelopment analysis by the use of production trade-offs", Journal of the Operational Research Society 58, 1261-1270, (2007).
Ramanathan R., "Performance of Banks in Countries of the Gulf Cooperation Council", International Journal of Productivity and Performance Management 56 (2) 137-154, (2007).
Ruggiiro J., "Data envelopment analysis with stochastic data", Journal of the Operational Research Society 55, 1008-1012, (2004).
Shanmygam R. and C. Johnson, "At a crossroad of data envelopment and principal component analyses", Omega 35, 351-364, (2007).
Sowlati T. and J. Paradi, "Establishing the frontier in data envelopment analysis", Omega 32, 261-272, (2004).
Thanassoulis S. E., "Introduction to the Theory and Application of Data Envelopment Analysis", Kluwer Academic Publishers:Dordrecht, (2001).
Yu M-M. and B. C. Y. Lee, "Efficiency and effectiveness of service business: Evidence international tourist hotels in Taiwan", Tourism Management 30, 571-580, (2009).
Wade D., L. Cook and M. Seiford, "Data Envelopment analysis (DEA)- Thirty years on", European Journal of Operational Research 192, 1-17, (2009).
Wang YM., KS. Chin and JB. Yang, "Three new models for preference voting and aggregation", Journal of the Operational Research Society 58, 1389-1393, (2007).
Wu J., L. Liang and Y. Chen, "DEA game cross-efficiency approach to Olympic rankings", Omega 37, 909-918, (2009).
Zamir I. Islamic Financial Systems, Finance & Development / June, (1997).

APPENDIX

Table 5. Anova analysis results by bank's type

ANOVA	
Analysis by bank type	**Sig.**
CRS_2005	0.29
VRS_2005	0.27
CRS_2006	0.74
VRS_2006	0.01
CRS_2007	0.37
VRS_2007	0.00
CRS_2008	0.13
VRS_2008	0.01

Articles	Sample (Banks)	Inputs	Outputs
Al-Faraj *et al.* (1993) "Evaluation of Bank Branches by Means of Data Envelopment Analysis"	15 Saudi Arabia	1. Employees, 2. Location, 3. Expenses, 4. Acquired equipment	1. Net profit, 2. Balance of current accounts, 2. Savings account, 3. Loans, 4. Number of accounts
Darrat *et al.*(2002) "Assessing Cost and Technical Efficiency of Banks in Kuwait"	8 Kuwait	1. Labor, 2. Capital, 3. Deposits	1. Loans, 2. Investments
Limam (2004) "Measuring Technical Efficiency of Kuwait Banks"	8 Kuwait	1. Fixed and unspecified assets, 2.Number of employees, 3.Capital	1. Earning assets
Grigorian and Manole (2005) "A Cross-Country Nonparametric Analysis of Bahrain's Banking System"	Different Numbers for different years: Bahrain, Kuwait, Qatar, Singapore, UAE	1. Personal expenditures, 2. Fixed assets, 3. Interest expenditures	1. Revenues, 2. Net loans, 3. Liquid assets
Al-Tamimi and Lootah (2007) "Evaluating the Operational and Profitability Efficiency of a UAE-Based Commercial Bank"	15 UAE	Operating efficiency model: 1.Employee expenses, 2.other operating expense Profitability efficiency model: 1. Interest expense, 2. Employees' expenses, 3. Other operating expenses	Operating efficiency model: 1. Value of total loans, 2. Total deposits, 3. Number of transactions Profitability efficiency model: 1. Interest revenue, 2. Non-interest revenue
Ramanathan. (2007) "Performance of Banks in Countries of the Gulf Cooperation Council"	55 GCC	1. Fixed assets, 2. Deposits, 3. Equity, 4. Personal expenses	1. Loans, 2. Other earning assets
Mostafa (2007) "Modeling the Efficiency of GCC Banks: a Data Envelopment Analysis Approach"	50 GCC	1. Assets, 2. Equity	1. Net profit, 2. Rate on assets (ROA), 3. Rate on equity (ROE)
Avkiran (2009) "Opening the Black Box of Efficiency Analysis: An illustration with UAE Banks"	15 UAE	1. Interest expense, 2. Non-interest expense	1. Interest income, 2. Non-interest income

Table 1: Recent literature on GCC banks' performance based on DEA