An application of Data Envelopment Analysis to study the Technical Efficiency of UAE banks in the pre and post crisis period

الكفاءة الفنية للمصارف (DEA)' لدراسة تنفيذا لتحليل مغلف البيانات
الإمارات العربية المتحدة في فترة ما قبل وما بعد الأزمة

By
Huma Anjum Siddiqui
Student ID - 100073

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Dissertation Supervisor
Dr. Elango Rengasamy

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Abstract

The rapid growth and development of the UAE banking sector over the past decade has seen increased competitiveness, technological advancements, booming economic conditions as well as a global financial meltdown resulting in tighter regulatory norms and increased emphasis on operational efficiency.

To this end, the present paper carries out a two stage analysis on 11 local commercial UAE banks, over the period of '2003-'2010. In the first stage, the technical efficiency scores of the sample banks are computed with the help of the output oriented, variable returns to scale, Data Envelopment Analysis technique.

The scores so arrived at in the first stage, were used in the second stage of the analysis, where the Tobit censored regression test was used to regress the dependent variables (the efficiency scores) against 4 selected variables, so as to understand whether these variables influence efficiency scores and if so, to what extent.

The findings indicated that the UAE banking sector was affected by the financial crisis based on the pre crisis (i.e. '2003-'2008) technical efficiency scores which reflected an ascending trend. Thereafter, a decline of 33.33% in the number of technically efficient banks was observed and it was inferred that DEA as a technique was able to reflect this trend.

The results of the second stage analysis showed that the size of a bank, the profitability (in terms of net income) and the market share of each bank positively influenced the technical efficiency scores, where an increase in these independent variables led to improved efficiency scores.

On the other hand, total equity (the proxy for bank capitalization) was found to be negatively related to efficiency scores, which meant banks with lower capitalization ratios had better efficiency levels and vice versa.

خلاصة

شهد النمو السريع وتطور القطاع المصرفي في الإمارات خلال العقد الماضي ارتفاعاً في وتيرة التنافس كما شهد في نفس الوقت أزمة اقتصادية طاحنة أدت إلى تشديد القواعد التنظيمية وزيادة التركيز على الكفاءة التشغيلية.

تم إعداد هذه الورقة التي تتضمن المرحلتين من التحليل لأحد عشر مصرفاً تجارياً محلياً بدولة الامارات التجارية وذلك خلال الفترة من 2003-2010 . ففي المرحلة الأولى ، تم حساب درجات الكفاءة الفنية لعينة البنوك بالاستعانة بمخرجات موجهة وعائدات متغيرة على المقياس وطريقة تحليل تطور البيانات.

في المرحلة الثانية من التحليل، تم استخدام اختبار المتغيرات التابعة (درجات الكفاءة) مقابل اربعة من المتغيرات المختارة، وذلك لفهم ما إذا كان لهذه المتغيرات تأثير على الكفاءة وإذا كان الأمر كذلك، إلى أي مدى.
بينت النتائج أن القطاع المصرفي في الإمارات تأثر بسبب الأزمة المالية استنادا إلى ما قبل الأزمة ('2003-'2008) .

وأظهرت نتائج تحليل المرحلة الثانية أن حجم البنك، ربحية (من حيث صافي الدخل) وحصتها في السوق من كل بنك أثرت إيجابا على الكفاءة التشغيلية، حيث الزيادة في هذه المتغيرات المستقلة أدت إلى تحسين الكفاءة .
من ناحية أخرى، تم العثور على مجموع حقوق المساهمين (وكيل لرسملة البنوك) لتكون ذات صلة سلبا على الكفاءة، الأمر الذي يعني ان البنك صاحب نسب رأس المال المنخفضة لديهم مستويات أفضل في الكفاءة والعكس بالعكس.

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This dissertation would not have been possible without the blessings and guidance of Almighty Allah and I am grateful for the strength and dedication which I was able to bring forward to carry out the research work.

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I joined The British University in Dubai with the hope of earning a Masters degree; however, I am graduating with a lot more than just a degree, with strong business and financial acumen and a genuine happiness of having been associated with my University. I thank each of you for having made this possible and hope the University grows from strength to strength in the years to come.

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1. Introduction

1.1. Introduction

Over the past decade, the world at large has witnessed a multitude of changes in the form of increased competitiveness, advancements in technology, booming economies and complex dealings in financial markets, eventually leading to a massive global financial meltdown resulting in increased risk awareness and tightening of regulatory banking norms.

The repercussions of these touched every corner of the world, and banks in the United Arab Emirates were no exception to this. Adding to this the Dubai real estate crash in '2009 and the strength of the banking sector in the UAE was tested thoroughly, with lessons being learnt the hard way.

Prior to the '2008 credit crisis, the banks in UAE focused solely on 'growth for growth's sake' by expanding their market reach and did not direct their attention towards creating an efficient platform for increasing profit margins (Bain & Company 2011). The report suggests that with the advent of the post recession recovery phase, UAE banks must look to re-investing in efficiency instead of just increasing client bases to increase profits.

This and the fact that an efficient and stable banking system contributes to increased economic prosperity in any country propelled the interest to study the impact of the crisis on the UAE banking sector and how it is pushing its way forward through the pre and post crisis periods.

This is, therefore, the motivation behind this study, as it is imperative for banks to focus on improved efficiency to ensure that they can survive and grow in such turbulent times.

Going forward with this, the present study looks to analyze the efficiency of local commercial UAE banks over the period of '2000-'2010, covering the pre and post crisis periods, to investigate the impact of the crisis therein. This paper uses a non parametric technique, Data Envelopment Analysis (DEA) in the first stage of the analysis, to measure banking efficiency, with the assumption of variable returns to scale (VRS). DEA is useful for benchmarking performing efficiencies of entities and was first used by Charnes, Cooper and Rhodes in 1978.

For the second stage of analysis, the Tobit censored regression test was applied and the efficiency scores computed in the first stage were used as dependent variables and then regressed against selected variables to understand if efficiency scores are influenced by the selected variables.

The objectives of the present study can be outlined as follows –

1) To analyze if the UAE banking sector was impacted by the financial crisis.
2) To estimate the efficiency scores of the UAE local commercial banks in the pre and post crisis periods and to observe if there was a declining trend in the scores before the crisis.

3) To add to the literature on the use of DEA as a technique for measuring technical efficiency and its usefulness.

The results of this study will indicate how the UAE banking system had been impacted by the financial crisis, how the sector has been shaping up in these turbulent times and what it is poised to achieve in the coming days.

1.2. The United Arab Emirates: Economy and Banking sector

The United Arab Emirates is a confederation of seven emirates, which are, Abu Dhabi, Dubai, Ajman, Sharjah, Umm al-Quwain, Ras al Khaimah and Fujairah. UAE accounts for nearly 10 percent of the world's crude oil reserves, where Abu Dhabi contributes towards half the country's GDP and Dubai accounts for another quarter.

While Abu Dhabi is at the forefront for oil activities, petrochemical and fertilizer industries and other energy based industries, Dubai leads the pack for real estate, being a financial hub, telecommunications, the re-export business, the retail business, leisure, travel and tourism and transport and logistics. The remaining emirates are dependent on light manufacturing, trade and financial support from the two largest emirates as well as the government.

The UAE is also part of the Gulf Cooperation Council, along with Kuwait, Qatar, Saudi Arabia, Oman and Bahrain, which was set up in the early 1980's to improve financial and economic relations in the region.

The UAE economy picked up pace from '2000, where it grew at a phenomenal rate from '2004 to '2008. The economic boom was a result of the real estate developments in Dubai, with large commercial projects which were financed by GREs (Government related entities).

Such GREs are a major source of growth in the UAE which are made up of commercial enterprises, financial institutions and investment bodies. These are owned directly by the Government of Dubai, the Government of Abu Dhabi (GAD) or companies which are largely owned and run by the ruling family (International Monetary Fund 2011).

With property prices peaking in '2008, the halt came about with the global meltdown in September '2008, followed by the debt crisis in Dubai '2009. With the real estate market going bust in '2009, its most apparent effects were visible in the UAE banking sector (Gulf Research Centre 2008).

With the financial crisis, the strength of the UAE banking sector was tested and as per '2012, the times ahead look challenging yet promising. With tightened cost-to-income ratios, the challenge lies in improving productivity and efficiency while managing costs effectively. It is hence suggested that banks look to reinvesting in efficiency, which is what will differentiate successful banks in the days to come.

Keeping this in mind, the present study analyzes the technical efficiency levels of local commercial UAE banks, considering the increased significance of operating efficiency in the current times.

The rest of the study will proceed as follows. Chapter 2 is a detailed literature review of DEA and studies carried in the UAE and GCC banking sector. Chapter 3 describes the data and methodology used in the present study, followed by a discussion on the empirical findings and results in Chapter 4.

Chapter 5 concludes the paper with the summary of the research and the findings.

2. Literature review

Published literature on the use of Data Envelopment Analysis as an efficiency measurement technique is expansive and vast. Specifically, the use of DEA in the banking sector for measuring efficiencies is growing as well. However, such studies are a lot more rampant in the developed economies, compared to studies carried out in the developing economies.

The review of published literature in this study first begins with DEA as an efficiency measurement technique and how it has evolved over the year. The review then proceeds to a discussion and summary of relevant DEA studies carried out in developing economies, specifically pertaining to the Middle East or the UAE banking sector.

To trace the origin of DEA, one is drawn to the seminal paper of Farrell (1957) where the concepts of efficiency and its computation were laid down. The rich ideas presented by Farrell in the paper formed the building blocks of research in this area for the next two decades.

This study provided two fundamental insights, one into the definition of efficiency and productivity and the other into how benchmarks and efficiency measures can be calculated. Farrell's study assumed the possibility of operations which are inefficient, which logically led to a benchmark concept underlined by an efficiency frontier production. This was a novel introduction in comparison to the average performance notion that was prevalent up until this paper was published.

Forsund and Sarafoglou (2002) study in detail the contributions of Farrell (1957) and clear the misconception that is widely believed about Farrell's paper receiving recognition only after Charles, Cooper and Rhodes (1978) (CCR) rediscovered the significant contributions of Farrell and built upon the same.

They analyze the developments in the field of economics which were inspired by Farrell (1957) and elucidate on the connection between Farrell and CCR.

Published literature includes two broad methods of estimating efficiency of banks, the parametric (or econometric) approach and the non-parametric approach. The non-parametric approach involves the estimation of an efficiency frontier, which is known as Data Envelopment Analysis.

This approach was made popular by the highly influential paper of Charles, Cooper and Rhodes (1978), which drew its facts from Farrell (1957) and went on to provide the estimates of firm-based technical efficiency (TE), allocative efficiency (AE) and overall efficiency (OE) under the assumption of constant returns to scale (CRS).

The CRS assumption was relaxed to allow for variable returns to scale (VRS) by Banker, Charnes and Cooper (1984) (BCC), resulting in the breakdown of TE into two parts, namely, pure technical efficiency (PTE) and scale efficiency (SE).

Coming to studies carried out with the use of DEA, we observe that there are a vast number of studies carried out all over the world, pertaining to banking efficiency using parametric or non-parametric methods, with a small percentage comparing the use of both methods. However, the number of efficiency studies carried out in the developing economies and more specifically in the GCC and UAE market is small and not as extensive as the developed economies.

In the present study, we discuss published literature of studies carrying out in the Middle East of UAE banking sector. We begin with Limam (2001), who estimated the technical efficiency of a total of 52 GCC banks from Bahrain, Kuwait, Qatar, Oman, Saudi Arabia and the United Arab Emirates, for the year ‘1999 using two methods. The first method used DEA for constructing a non-parametric linear frontier while the other method used a Correcting Ordinary Least Squares (COLS) technique for constructing a parametric frontier.

The study adopted the intermediation technique for defining the three inputs (fixed assets, number of bank employees and financial capital, which included deposits, borrowings and any liabilities that are not classified under borrowings or deposits) and the two outputs (all types of loans provided by banks and bank deposits and investments).

Based on the results arrived at, it was inferred that GCC banks have scope to improve their technical efficiency, on an average, by 10 percent. The author also concluded that Bahrain and the Kingdom of Saudi Arabia hosted banks which were more technically efficient than other countries. This was attributed to the environment in which the banks operated in these two countries, which is considered to be conducive to increased efficiency.

Further, the results of the OLS estimation test indicated that a larger bank size and higher level of equity capital were associated with increased technical efficiency. On the other hand, there was a weak link between profitability and higher technical efficiency as well as the date of establishment with improved technical efficiency.

With this, the author concluded that environmental and regulatory factors may be affecting the efficiency of GCC banking operations and it would be worthwhile to study the impact of these on the technical efficiencies of GCC banks.

Along the same lines, Mostafa (2007) conducted a DEA of the top 50 banks of the six GCC countries, Bahrain, Kuwait, Qatar, Oman, Saudi Arabia and the United Arab Emirates, for the year ‘2005 using cross sectional data.

The five variables were selected using the intermediation approach, with two inputs, namely, assets and equity and three outputs which were net profit, rate on equity (ROE) and rate on assets (ROA). The study was carried out using both, the CRS and VRS approach since the VRS technique measures pure technical efficiency (TE) only and by using the CRS technique, a scale efficiency measurement can also be arrived at.

The CRS model results indicated efficiency scores ranging from 13 to 100 percent, compared to a range of 20 to 100 percent efficiency scores using the VRS model. The average efficiency of banks was 55 percent based on the CRS model and 73 percent using the VRS model, while the standard deviation between the two methods was similar, with 22.1 percent using the CRS model and 22.8 percent using the VRS model.

The study thus concluded that the results arrived at are in line with previous studies that state that DEA efficiency scores computed using the CRS assumption are less than or equal to corresponding VRS efficiency scores (Banker, Charnes & Cooper 1984).

Another study that compared banks of different countries was that of Grigorian & Manole (2005). In this study, the DEA technique was used for studying the Bahrain banking sector and how competitive it is in the regional context, vis-à-vis banks in Kuwait, Qatar, the United Arab Emirates and Singapore, for the period ‘1997 to ‘2002.

The study used the intermediation approach with three inputs, namely, personnel expenditures (proxy for labor input), fixed assets (proxy for premises, branch network and equipment) and interest expenditures (proxy for the amount of leveraged funds used in the process of intermediation).

The three outputs used in the study were revenues (which was defined as the sum of non-interest and interest income), net loans (defined as loans net of loan loss provisions and liquid assets (which was defined as the sum of cash and treasure bill holdings along with balances with monetary authorities)

Based on the results arrived, the author concluded that Bahrain banks were as scale efficient as Singapore banks, followed closely by banks in Qatar and the United Arab Emirates. The overall efficiency results however, indicated Singapore banks as the most efficient with Bahrain banks leading the way amongst the remaining sample GCC countries. Their study also indicated that conventional and non-conventional (Islamic) banks did not exhibit statistically significant differences in terms of efficiency scores.

In contrast, Alsarhan (2009) found that Islamic banks were associated with higher levels of efficiency in comparison to conventional banks, with a strong relationship between Islamic banks and higher efficiency scores. This was similar to the results of Hussein (2004).

Alsarhan (2009) used a two-stage approach to measure and analyze the technical efficiency of 50 GCC banks from ‘2000 to ‘2007, using DEA with the variable returns to scale (VRS) assumption.

The Tobit regression model was employed in the second stage, where the efficiency scores obtained in the first stage were regressed on three factors (total assets, return on equity and Islamic bank as a dummy variable).

The first stage results indicated that the banking sector of the GCC countries had a steady increase in the average efficiency scores in almost all countries. Banks in Qatar showed the highest overall score (except for ‘2006 and ‘2007), while Bahraini banks showed the most improvement with its average efficiency score increasing by 22.26% over the sample period.

On the flip side, Saudi Arabia was the only country where the banks reflected a decrease in its average efficiency scores.

The most efficient banks were found to be in Qatar, followed by the UAE and Bahrain. This was attributed to the developed banking industry space in these countries as well as increased foreign entities presence, resulting in increased competitiveness.

The second stage results showed a positive correlation between the size of the total assets and efficiency scores, as well as profitability (defined by Return on Equity (ROE)) and efficiency scores. Similarly, Islamic banks were seen to have high efficiency scores.

Since Islamic banks are less risky in their operations, holding a higher cash-deposit ratio than traditional banks, they are, on an average, more profitable than their conventional counterparts (Olson & Zoubi 2008). This was cited as a possible reason for the higher efficiency scores achieved by Islamic banks.

Al-Jarrah and Molyneux’s (2003) study also indicated a similar result. However, their study employed the Stochastic Frontier Approach (SFA) for 82 selected MENA banks (i.e. banks of Bahrain, Egypt, Saudi Arabia and Jordan) over ‘1992-‘2000. They concluded that Islamic banks were the most profit and cost efficient, with Bahraini banks the most profit and cost efficient and the least efficient were investment bank.

Another SFA study was employed by Ariss (2008) to analyze the Lebanese banking sector’s performance during ‘1990 to ‘2001 in the post war time period. The six inputs and outputs were selected using the intermediation approach, where the three inputs were the unit price of capital, the unit cost of funds and the unit price of labor and the three outputs selected were customer loans and discounts, liquid assets and net fees and commissions.

The results demonstrated an increase of 10% in the average efficiency of the Lebanese banking sector. The author stated that the efficiency level could further increase with improving inter bank competitiveness as also by the deregulation by monetary authorities.

Moving to studies conducted in banking sectors of single countries, we see Yildirim’s (2002) study where he applied DEA to the Turkish banking sector during ‘1988 to ‘1999, because this period was marked by increasingly unstable macroeconomic conditions. With the use of intermediation approach, four inputs, namely, total time deposits, total demand deposits, total interest expense and total non-interest expense were selected.

The three outputs specified were interest income, total loans and non-interest income. The empirical results of the study suggested that the Turkish banking sector did not achieve sustained efficiency improvements over the sample period and the volatile macroeconomic environment seemed to be responsible for this trend.

There were wide variations in the pure technical and scale efficiency measures as well. Further, it was found that efficient banks reported higher profitability while scale inefficiency and pure technical efficiency are positively related to bank size.

Similar to Yildirim's (2002) study, Erdem and Erdem (2008) also studied the Turkish banking sector, for the time period of '1998 to '2004. They used DEA to study the technical, allocative and economic efficiency scores of the commercial banks which are listed on the Istanbul Stock Exchange.

Assuming the intermediation approach, the study used three inputs, namely, number of full time employees, physical capital and interest bearing liabilities and one output, which was profit before tax.

With these, the authors investigated whether the period of financial crisis from '2001 to '2003 affected the banking system's efficiency levels. The banks' efficiency scores were then related to their corresponding stock prices to determine if the efficiency scores influenced the returns from stocks or not.

The results obtained indicated that the crisis did affect the efficiency levels, with the efficiency scores declining in '2001 (from 0.781 to 0.504), which improved after this year, except for year '2003. Six banks were also found to be technically efficient at least once during the sample period.

Further, no statistically significant conclusion could be inferred to explain the relationship between bank efficiency scores and movements of stock price return.

Another study was carried out in Jordan, by Barakat (2003) who used SFA to study the economies of scale and economies of scope of 21 Jordan banks, from '1990 to '2000, as well as an analysis of the competitive conditions prevailing during the period of the study. Using the intermediation approach, three inputs and two outputs were selected, which were labor, capital and deposits and loans and investments, respectively.

The results of the study showed that apart from two banks, all other banks indicated increasing returns to scale. During the sample period, the Jordanian banks' cost curves were also found to be downward sloping and the author therefore supported the merger policies of the Central Bank of Jordan (since mergers result in improved scales of banks).

Further, on analyzing the competitiveness in the banking environment, the author found that decreased competitiveness negatively impacted efficiency levels. Based on this, it was noted that merger policies should be judged accordingly by Jordanian policymakers, to ensure that a dilution in competition by way of mergers does not result in declining efficiencies.

Another study conducted on the Jordanian banking sector was by Ahmad (2000) who analyzed the efficiencies of 20 Jordanian banks, from ‘1990 to ‘1996, using both DEA and SFA. The two inputs (labor and deposits) and two outputs (loans and investments) were determined using the intermediation technique.

The average cost efficiency of the banks arrived at by using both the methods were compared and it was found that the efficiency was 73.5% using DEA and 77.5% using SFA. The results also showed that national banks were lesser efficient than foreign banks, while small banks indicated higher efficiency levels than large and medium sized banks. Large banks were also found to be most profit efficient, followed by medium and small sized banks.

Amongst the policy recommendations made in the study, one was similar to the one made by Barakat (2003) about circumventing mergers since they result in lesser competition and instead, improving the level of bank capital by ways other than mergers. Higher level of supervision by the Central Bank of Jordan and increasing foreign investment in the Jordanian banking sector were other suggestions made in the study.

Next, an interesting study on the UAE banking sector was carried out by Al Shamsi, Aly and El-Bassiouni (2009) who used DEA to analyze the economic efficiency (i.e. allocative, technical, pure technical and scale efficiency) in ‘2004 for a cross section of UAE banks.

With the help of the intermediation technique, the authors determined three inputs, namely, labor, capital and deposits and two outputs, namely, loans and investments.

The results indicated that allocative inefficiency is the main cause of inefficiency in the UAE banking sector, rather than technical inefficiency. Technical inefficiency is further found to be caused by pure technical inefficiency and not by scale inefficiency.

Other insightful findings indicated how UAE banks which have more branches are better able to use their input resources compared to banks which have lesser branches. On an average, newer banks were found to be performing better than established banks and banks with employees with lesser experience resulted in decreased efficiencies.

The efficiency levels were also found to vary with the level of government ownership (i.e. banks with higher levels of government share had lower efficiency scores and vice versa). Most interestingly, banks with higher level of female employees, more managers and fewer UAE nationals as employees were found to be operating at higher levels of efficiency.

Further, Al-Faraj, Bu-Bshait and Al-Muhammad (2006) applied DEA to the commercial Saudi banking sector for the year ‘2002 to study the technical efficiency of the banks and then compared these scores with the mean of the world efficiency scores.

The 9 banks were evaluated with two inputs (interest and non-interest expenses) and two outputs (net interest and non-interest income), where the inputs and outputs were determined using the intermediation approach.

Based on the results, it was found that the commercial Saudi banking sector’s efficiency levels were higher than the average of the world efficiency scores. In order to sustain the efficiency levels, it was then suggested that Saudi banks continue to adapt to the latest technological advancements and also offer newer services such as Islamic financing products, insurance services and mortgage financing etc.

Another UAE banking sector study was conducted by Budd and Budd (2006) who used DEA with Tobit models to analyze the efficiencies of 21 commercial local UAE banks over the period of ‘1998-‘2004. The study aimed to evaluate whether the record profits being enjoyed by UAE banks are consistent with high efficiency scores or if they are concealing inefficiencies.

The authors used the intermediation technique to select the three inputs variables, namely, the total number of full time employees (L), the total capital (K) (i.e. non-current fixed assets) and total deposits (D) (i.e. deposit liabilities due to customers and banks deposits). The two outputs selected were total loans (LA) (i.e. loans and advances made to customers) and total investments (H) (taken to be the value of all securities excluding those which are held in the bank’s accounts such as government debt, investment securities, treasury bills and bonds).

The study evaluated the allocative efficiency (AE), technical efficiency (TE) and cost efficiency (CE) using the constant returns to scale (CRS) assumption (i.e. the CCR approach) for ‘2004 and then studied the pure technical efficiency (PTE) and scale efficiency (SE) using the assumption of variable returns to scale (VRS) (i.e. the BCC approach). In this way, five levels-based efficiency measures were computed for year ‘2004.

Further, based on the CRS assumption, the Malmquist Index (MI) can be divided into technical efficiency change (TEC) and technological change (TC). Using the VRS assumption, the TEC can further broken into pure technical efficiency change (PTEC) and scale efficiency change (SEC). In this way, these five change-based productivity measures were also computed for the period ‘1998-‘2004.

The results provided evidence of cost inefficiency and over-banking in the sector, despite the increasing profits. Bigger banks were found to be more efficient based on the levels-based measures. Further, the change-based measures showed a reasonable improvement in the productivity of the banking sector over the six year period. The authors therefore concluded that increasing profits will not be enough to sustain the sector, which is where the importance of efficiency comes into picture.

A more recent study is by Assaf, Barros and Matousek (2011) who applied a two-stage DEA technique to study the technical efficiency of nine Saudi Arabian banks during ‘1999-‘2007. With the help of the intermediation approach, the authors selected three inputs, which were the total number of employees, total deposits and fixed assets as well as three outputs, namely, securities, customer loans and interbank loans.

The first stage of the study saw the variable returns to scale (VRS) assumption being utilized to construct the efficient frontier, after which a bootstrapped truncated regression model was used in the second stage of the study, to explain how variables (or covariates) were influencing the technical efficiency of the banks.

The results indicated that Saudi Arabian banks had increasing average efficiency levels since ‘1999, touching an average efficiency level of 90.21% in ‘2007. It was also seen that banks performed decreasingly well on the efficiency front over the period of ‘1999-‘2003, after which a consistent improvement in technical efficiency till ‘2007.

The second stage regression results indicated that large sizes are proportionately related to increasing technical efficiency levels and vice versa. Banks with higher levels of technical efficiency would also have smaller net profit margins and vice versa.

Lower technical efficiency was also related to banks which retained lesser profits (i.e. banks which had a high dividend payout ratio), thus suggesting that to increase efficiency levels, banks should look to retain more profits and invest these in latest technologies, branch networking, product development etc.

Lastly, efficiency levels of banks with foreign capital were found wanting and it was concluded that foreign capital does not bring in managerial efficiency in the case of the Saudi banking sector, which was contradictory to results obtained by previous studies.

Lastly, Akhtar (2010) estimated the DEA and Malmquist productivity indices of Saudi Arabian banks over the period of ‘2000-‘2006. The study used the intermediation approach to select two inputs (interest expenses and non-interest expenses) and two outputs (net interest income and non-interest income).

In the study, technical efficiency (TE) was computed, which was divided into its components, pure technical efficiency (PTE) and scale efficiency (SCE). The results showed that Saudi banks were operating at sub optimal levels of technical efficiency (and its components pure technical efficiency and scale efficiency indicated the same).

Lower levels of technical efficiency as well as its components were seen in the year ‘2001 and a similar trend was exhibited by the indicators of profitability (return on equity (ROE) and return on assets (ROA)) for ‘2001.

On the other hand, the MPI scores indicated banks had increasing average productivity during the sample period, which was attributed to technological and efficiency changes. Here, the technological changes had a larger contribution than efficiency changes to productivity gains.

Thus, the literature review of the aforementioned papers reiterates the significance of DEA as an efficiency measurement technique and the useful insights that it gives into efficiency parameters and how they are influencing the efficiency scores. The findings and results of the different studies also provide excellent yardsticks for comparative and informational purposes.

The review also helps understand the different combinations of input and output variables that have been selected and the same understanding has been applied in the present study.

The next section describes the data selection, the input and output variables, the model formulation and the methodology in detail.

3. Data and Methodology

3.1. Technical Efficiency: The Concept

The term technical efficiency can be defined as the minimization of inputs, which are used for the production of a given set of outputs. Alternatively, technical efficiency is achieved with the maximization of outputs, from the use of a given set of inputs (Kumbhakar & Lovell 2000). From this, it is clear that a production unit or economic entity is said to be operating at technically inefficient levels when it uses an excessive amount of inputs or produces a lesser than optimal outputs.

Since the measurement of technical efficiency does not require any information on prices of the goods (or services) or the imposition of any behavioral objectives on the banking entity (or on the 'producer'), frontier analysis can be appropriately used for analyzing the efficiency levels of the banking sector, being an industry that 'produces' financial products and services.

Hence, banks, which are similar to other economic entities, also utilize scarce resources for their operations and must strive to reach the optimal input-output mix accordingly. Based on published literature, an efficient bank is one that works with a production plan that minimizes costs with a given output mix and input prices or one that maximizes profits with a given set of input prices and outputs (Hughes & Mester 2008).

Inefficiency arises when a bank has a sub-optimal operating mix, i.e. using more inputs or produces less output. This is where the significance of using techniques for measuring efficiency becomes evident.

While analysts earlier used to employ cost and profitability ratios to study the efficiency of banks, the rationale behind using these were quite debatable. Cost ratios measured efficiency by evaluating the overhead expenditure (such as on bank premises and personnel), relative to the quantity of financial products and services provided by the bank. Since the emphasis was on cost cutting, inferring that reduced (or increased) spending on overheads results in more (or less) efficiency would be incorrect.

3.2. Parametric Methods Versus Non Parametric Methods

In more recent times, however, the use of various parametric (or econometric) and non parametric methods has become prevalent, where efficiency, as theorized by Farrell (1957), is estimated based on realized deviations from an ideal (or efficient) frontier.

Parametric methods include mainly three techniques, which are the Stochastic Frontier Analysis (SFA), Thick Frontier Analysis (TFA) and Distribution Free Approach (DFA), amongst which the SFA is most popular for evaluating efficiencies of banks.

Non parametric methods on the other hand, include the Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH) techniques. Again, the DEA is a more popular parametric method used in published literature for measuring bank efficiencies.

Since parametric (i.e. SFA) and non parametric methods (i.e. DEA) use a distinctively different approach for constructing the efficiency frontier, there has been debate and consideration as to which of the two methods are more suitable to evaluating bank efficiencies.

Based on studies comparing the efficiency results arrived at with the use of DEA and SFA, it is clear that there are differences between the results, which are partly attributed to the differences in the way the techniques construct the frontier itself. For instance, the empirical study of Delis, Koutsomanoli-Fillipaki and Staikouras (2009) on the cost and profit efficiencies of Greek commercial banks over the period of '1993-'2005 found substantial differences between the results provided by the two methods.

Similarly, Kumar and Arora (2010) examined the technical efficiency of the Indian banking sector over the period of '1991-'2007 using both DEA and SFA and provided evidence of conflicting results provided by the two methods on the relative efficiency scores, relative rankings of sample banks and differences in the identification of high and low efficiency banks. Apart from these differences, both the techniques indicated improved efficiency of the banks over the study period.

It is thus clear that a consensus on which of the two methods is a better fit for measuring efficiency, whether for certain types of banks, economies or other differentiating factors is still open to debate and research. More importantly, it is not specifically important to study which of the two methods is a superior measure of efficiency. Instead, it is of significance to understand how both the methods can be integrated to bring about further precision in the estimation and analysis of efficiency of banks (and other entities).

Comparing the pros and cons of both SFA and DEA, it is clear that both methods employ efficiency measurement techniques which are quite distinct and selecting one technique would mean trading off strengths of another and vice versa (Gannon 2005). SFA, a parametric technique, uses regression while DEA, a non parametric technique, uses linear programming.

The SFA requires an assumption on the specific functional relationship between production input and output as well as an assumption of the statistical distribution of the random error and inefficiency terms. Since DEA does not require any such assumptions, it scores an advantage over the use of SFA since the possibilities of assuming an incorrect functional form is avoided.

Also, SFA requires a large sample data set to make reliable assumptions (Havrylchyk 2006) and DEA circumvents this problem since it is able to estimate efficiencies well with a small sample data set, making it a suitable technique to use for the present study of 11 local commercial UAE banks.

Further, unlike a stochastic frontier formulation, DEA allows for the use of multiple inputs and outputs and requires (little or) no price information. DEA helps in identifying the 'role model' firm or firms with the best practices because it provides information on the efficiency of each decision making unit (DMU), vis-à-vis the efficiency frontier benchmark as well as efficiency information relative to specific units which are efficient (Kumar & Arora 2010).

Lastly, developing economies such as the UAE have imperfect market conditions, resulting in distorted prices of input and outputs variables. In this scenario, applying parametric techniques (or SFA) would be inappropriate as it would complicate the measurement of efficiency levels (Bhattacharya, Lovell & Sahay 1997).

Based on the aforementioned reasons, the present study selected the non parametric method of DEA to estimate the technical efficiency of banks in the UAE.

3.3. Introduction to Data Envelopment Analysis

Data envelopment analysis is a non parametric technique used for measuring operating performances of economic entities, often using a linear programming method (or a frontier analysis technique).

Farrell (1957) had laid the theoretical underpinnings for DEA by describing concepts of efficiency and how efficiency benchmarks and measures can be computed thereof. The study was therefore, novel in its approach by assuming the existence of operations which may be inefficient, consequently leading to an efficient frontier benchmark concept.

These ideas were the building blocks of the model put forward by Charnes, Cooper and Rhodes (1978) (CCR) which assumed constant returns to scale (CRS).

The DEA method compares the efficiency score of each decision making unit (DMU) relative to that of its peers and then assigns an efficiency score to each DMU. The efficient frontier is made up of DMUs which are found to be ‘benchmarks’ or ‘best performers’. DEA arrives at this by solving a linear programming problem using the input and output variables selected for the study to result in a non stochastic (i.e. excluding an error term in the model) and non parametric production frontier.

The present study selected DEA as the technique for evaluating the technical efficiency of banks, since published literature has found it to be a good indicator of efficiency levels across banking sectors for various reasons.

Firstly, DEA is an evolved and practical technique which uses efficient frontiers for its estimation of efficiency levels instead of the linear models which used central measures of tendency or financial ratios. This makes it convenient to compare the various decision making units (DMUs) on set parameters.

Secondly, in comparison to other parametric techniques of evaluation (such as Stochastic Frontier Analysis or SFA), DEA does not require an exact specification of the functional form of the production frontier and neither does it require a distribution which has the deviations of inefficiency from the frontier. Instead, DEA assumes general production and distributions facets, thus minimizing the possibilities of making an incorrect assumption for the production function.

Further, DEA can handle multiple inputs and outputs vis-à-vis parametric methods which can use single inputs and outputs only. DEA thus facilitates the analysis and quantification of the specific sources of inefficiency in each DMU. Studies have also enumerated how DEA uncovers aspects of economic relationships that may remain unconcealed with the use of other techniques.

On the flip side, a limitation of the deterministic (i.e. a model that does not use a random error term) DEA model is that the efficiency scores arrived at cannot distinguish between actual inefficiency and inefficiency caused due to 'noise'. This gives a skewed picture of inefficiency levels since all deviations from the efficiency frontier are considered to represent inefficiency (Canhoto and Dermine 2003).

The aforementioned positives were the motivating factor behind using DEA as the tool for measuring technical efficiency of UAE banks in the present study.

The basic DEA model as proposed by Charnes, Cooper and Rhodes (1978) i.e. the CCR model, has an objective of maximizing the efficiency of a firm K, amongst a (sample) set of S firms, by selecting input and output variables with optimal weights. Since the maximum value of efficiency is constrained to 1, a firm which has an efficiency score of 1 is considered to be efficient, while those that have efficiency scores lesser than 1 are inefficient.

The model is represented by the following formulation –

$$\text{Maximize } E_{kk} = \frac{\sum_y O_{ky} V_{ky}}{\sum_x O_{kx} V_{kx}}$$

Subject to:

$$E_{ks} \leq 1 \forall \text{Firms } S,$$

$$U_{ks}, V_{ks} \geq 0 \qquad (1)$$

Where, E_{ks} = Efficiency score of Firm S, using the weights of test Firm K;
O_{sy} = Value of output y for Firm S;
I_{sx} = Value of input x for Firm S;
V_{ky} = Weight assigned to Firm K for output y;
U_{kx} = Weight assigned to Firm K for output x.

The following model (i.e. model 2) represents the linear programming problem which is equivalent to the non-linear programming model as explained above -

$$\text{Maximize } E_{kk} = \sum_{y} O_{ky} V_{ky}, \qquad (2)$$

Subject to:

$$E_{ks} \leq 1 \forall \text{Firms S},$$

$$\sum_{S} I_{ks} U_{ks} = 1$$

$$U_{ks}, V_{ks} \geq 0$$

Thus, model 2 is transformed into the linear programming problem by adding the constraint $\sum_{s} I_{ks} U_{ks} = 1$. This model indicates a simple optimal technical efficiency value, given by E^{*}_{kk}, that can take the highest value of 1.

Thus, if $E^{*}_{kk} = 1$, it can be understood that only Firm K is efficient for the selected weights and only Firm K is on the optimal frontier, without being dominated by any other firm. However, if $E^{*}_{kk} < 1$, then Firm K does not lie on the optimal frontier and for the optimal set of weights as determined by model 2, there is at least one other firm that is more efficient than Firm K. This formulation is repeated S times for each firm.

The dual of the CCR model can then be explained as followed –

$$\text{Minimize } \theta,$$

Subject to:

$$\sum_{S} \lambda_{s} I_{sx} - \theta_{sx} \leq 0 \forall \text{ inputs I},$$

$$\sum_{S} \lambda_{s} O_{sy} - O_{ky} \geq 0 \forall \text{ outputs O}, \qquad (3)$$

$$\lambda_{s} \geq 0 \forall \text{Firms S},$$

Where θ is the efficiency score.

The Model as proposed by Charnes, Cooper and Rhodes has an assumption of constant returns to scale (CRS) for the input and output variables. This model was later extended by Banker, Charnes and Cooper (1984) (known as the BCC model) to account for variable returns to scale (VRS).

The difference between these two models lies in the assumption of constant returns to scale versus variable returns to scale. In CRS, it is assumed that regardless of the size of the DMU, outputs are said to be directly proportional to the change in inputs. Thus, CRS would be an inappropriate assumption for a sample data set that comprises of DMUs which have large scales of operations (i.e. with large scale of operations, ‘economies of scale’ comes into picture and this logic is not applied in the CRS assumption).

On the other hand, the VRS assumes that a change (increase or decrease) in inputs does not cause a proportionate change in the outputs. It is thus assumed that as a DMU grows larger; the average cost of its operations would either fall or rise.

In this way, the BCC model helps in determining the pure technical efficiency of a set of DMUs. The formulation for this model includes an additional convexity constraint which is defined by placing a limitation of the summation of the multiplier weights (i.e. λ) of 1. The constraint is defined as follows –

$$\sum_{S}\lambda_{s} = 1 \qquad (4)$$

Therefore, it can be noted that while the CCR model with CRS assumes that the inputs are directly proportional to the outputs, the BCC model with VRS assumes that the inputs are not directly proportional to the outputs (or an increase or decrease in inputs does not result in a proportional increase or decrease in outputs).

In this way, the BCC model estimates how decreasing, constant or increasing returns to scale could improve the efficiency levels observed. Used together, the CCR and BCC model can help in evaluating the overall levels of technical and scale efficiencies of a firm and can help in evaluating if the sample data used exhibit variable returns to scale or not (Sarkis 2000).

3.4. Data

The secondary sample data for this study has been procured from the BankScope database, which is an International database with up to date and comprehensive information of banks around the world. The database has information on bank financial statements, ratings and intelligence as well as economic profiles of countries and their outlooks.

The annual sample data of 8 years from ‘2003 to ‘2010 of 17 local commercial UAE banks were collected from this database. The local Islamic UAE banks were not included in the sample set to ensure a level playing field so that the efficiency levels of the conventional banks could be suitably analyzed. Similarly, branches of foreign banks operating in the UAE were also excluded from the sample data.

From the 17 local commercial banks’ data, those which were merged as well as those with missing data and/or negative financial figures were also excluded. This was done since Portela, Thanassoulis and Simpson (2004) explain how there is no DEA model that can utilize the negative figures directly without having to first transform them. Hence, banks with such data were excluded since DEA requires data for inputs to be strictly positive and that of outputs to be non-negative (Sarkis & Weinrach 2001). After data cleaning, the number of local commercial banks selected for the study were 11 in number, with data for a period of 8 years (i.e. 88 data points).

Once the banks and their data were secured, the next step comprised selecting the specific inputs and output variables that would be applied in the DEA model. This is a crucial step since the variables have to be selected based on the type of efficiency that is to be evaluated (Sherman & Rupert 2006).

According to Casu and Molyneux (2003), currently there are no set parameters for defining the inputs and outputs which should be selected for measuring banks' efficiency. However, there are two broad methods which are used for selecting the inputs and outputs for banking efficiency studies, as described by Berger and Humphrey (1997). These are the production approach and the intermediation approach.

Based on the production approach, a bank is considered as an entity which delivers financial products and services to its customers (or clients) by way of transactions. When a benchmarking model is then used, the aim is to understand how efficiently the banks are able to combine their limited resources to maximize their operational profitability by achieving the number of transactions.

The intermediation approach on the other hand considers banks to be an entity that primarily intermediates funds from the savers to the investors and vice versa. This approach hence considers that a bank purchases liabilities, so as to transform these into earning assets (Assaf, Barros & Matousek 2011). Further, in the intermediation approach, monetary units are used to measure the inputs and outputs.

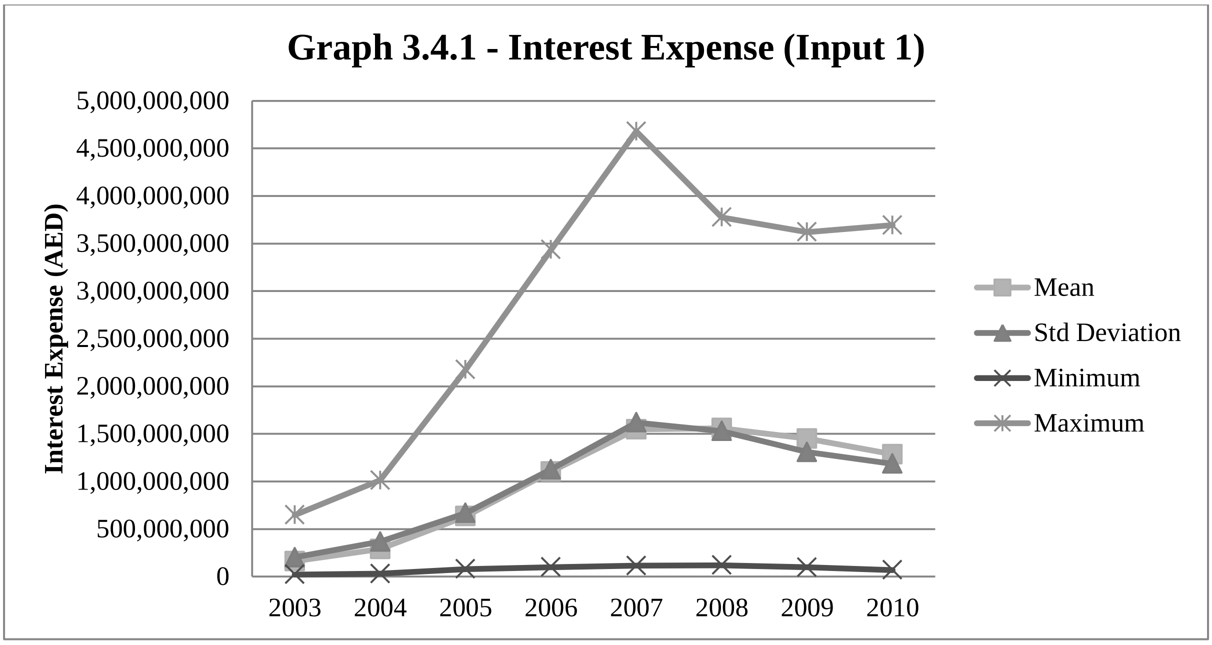
Thus, based on the aim of the present study to assess the technical efficiency of banks in the UAE, the intermediating functions performed by commercial banks as well as the evidence presented by recent literature, it was decided to select interest expenses and non interest expenses (i.e. operating expenses) as inputs and net interest income and non interest income as outputs. These inputs and outputs are similar to those used by Al-Faraj, Bu-Bshait and Al-Muhammad (2006) and Akhtar (2010) in the Saudi Arabian banking sector.

Banking literature describes how interest and non interest expenses are significant in determining the productivity of banks. Efficient operations would be maintained when a bank is able to generate higher levels of revenue from both interest and non interest sources, while a reasonably low ratio of non interest expenses to total expenses is also a mark of efficiency. In this way, the efficiency levels computed in this study will, at the simplest level, reflect the efficiency of UAE banks in converting costs into revenues.

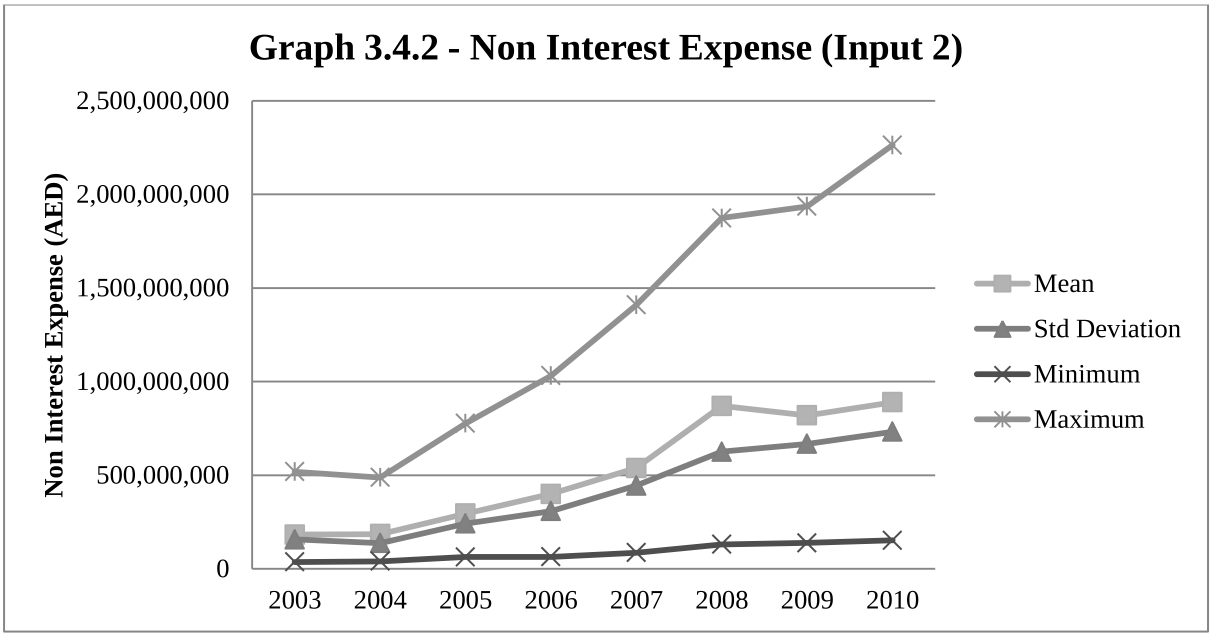
It should be noted that the types of variables selected for the study are constrained by the availability of the data. However, based on studies which have also used similar input and output variables, it can safely be assumed that the variables satisfy the requirements of the aim of the present study as well.

The descriptive statistics of each of the input and output variables were tabulated (See Appendix 1) and the statistics were compiled for each year for each variable to analyze the data graphically.

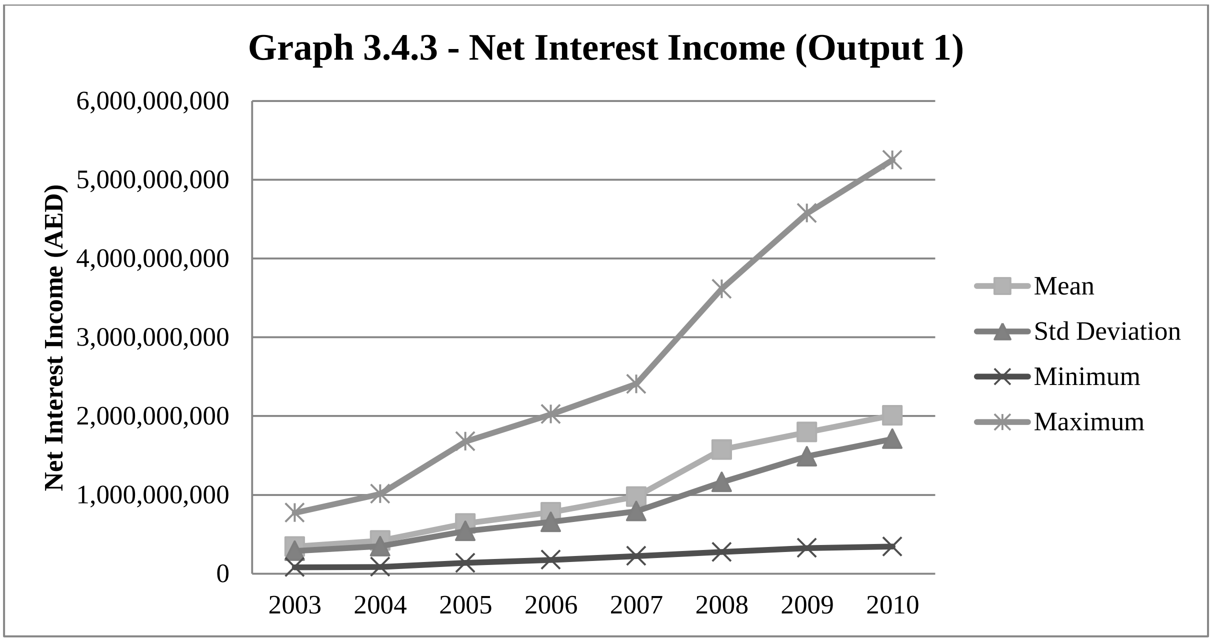
From graph 3.4.1, it can be noted that the mean interest expenses of all sample banks reached a peak in ‘2007, after which there was a decline in ‘2008-‘2010. Interest expense, which is purely the cost of borrowing, increased till ‘2007, indicating how UAE banks were on a borrowing spree and from ‘2008, the banks were forced to cut down on their interest expenditure given the financial bubble that burst.



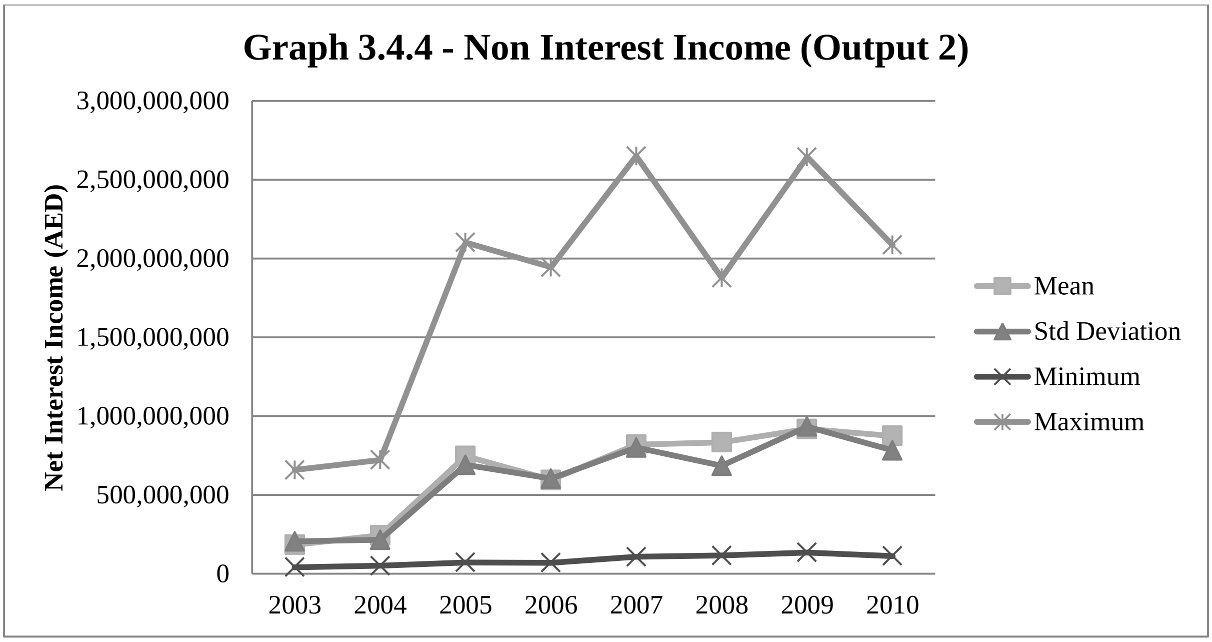
The non interest expenses (graph 3.4.2) show an ascending trend and by analyzing the income statements of banks, it was noted that the personnel expenses of the sample banks as well as other operating expenses were on a rise, resulting in the ascending trend over the sample period.



Similarly, it was noted that UAE banks' net interest income was increasing consistently throughout the sample period of '2003-'2010 (graph 3.4.3).



The non interest income however, showed a fluctuating trend over the sample period (graph 3.4.4). On analyzing the income statements further, it was found that net interest income, which comprises net gains (or losses) on trading and derivatives, net gains (or losses) on other securities, net gains (or losses) on assets at fair value through the income statement, net insurance income, net fees and commissions and other operating income, was affected by the losses on assets at fair value, thus resulting in increasing and decreasing net interest income through the years.



Another point that must be highlighted is the decision regarding the number of variables that is considered optimum for carrying out the DEA study appropriately. DEA is found to be sensitive to the number of variables selected, since the ability of the method to discriminate between the efficient and inefficient DMUs decreases as the number of variables used in the study increases.

That is, as more and more variables are used in the study, the chances of an inefficient DMU becoming efficient by dominating in the added dimension increases (Smith 1997). Therefore, in order to maintain the discriminatory ability of the DEA methodology, it is prudent to keep the number of inputs and outputs to the appropriate level.

What this appropriate level should be is not set out or defined specifically. However, Feroz, Kim and Raab (2003) recommend that for a country with smaller number of banks, DEA can be applied if the number of sample DMUs is not lesser than the product of the number of inputs and outputs. This condition is satisfied for our study, where the product of the number of inputs and outputs is 4, which is lesser than the number of sample banks, which are 11 in number.

3.5. Model Specification and Data Analysis

To carry out the DEA study, there are three characteristics of the model which must be decided upon. They are the returns to scale (whether CRS or VRS), the orientation of the programming problem (i.e. the definition of the objective function as input or output oriented) and the valuation system (selecting the weights that are placed in the input and output objective function, subject to the inequality constraints).

This study uses VRS since the aim is to analyze the technical efficiency levels across the UAE banking sector, which is predominantly an imperfect market and it is known that in such imperfect competition, a DMU may or may not be operating at the optimal scale. Since the CRS assumption can be appropriately used only when all DMUs are operating optimally, the VRS assumption (or the BCC model) was suitably selected for this study.

It was also noted by Alsarhan (2006) that in recent years, the VRS technique has been most commonly used, since it reflects the true observations found in the real world more clearly. The VRS scores indicate only pure technical efficiency levels of DMUs and based on this, along with the aforementioned reasons, VRS was chosen for this study.

Further, the orientation of the DEA formulation can be input oriented or output oriented. Input orientation should be selected if firms are looking to increase or decrease the use of inputs, to maintain the level of outputs they currently have. An example of this would be firms in the manufacturing industry where they have to satisfy requirements of customer orders.

The output orientation however, is suited to industries where the same level of inputs is to be used to maximize the outputs at much as possible. Hence, in firms where the input quantities are the primary variables of decision making, input orientation should be used, while in firms where managers have more control over output variables, the output orientation would be more appropriate (Coelli et al. 2005).

It can also be noted that the orientation chosen influences the efficiency scores arrived at only to a small extent (Coelli & Perelman 1999). In our case, output orientation has been selected since it is known that banks would look to increasing their market share instead of cutting down on the inputs (or resources) used.

Lastly, the valuation system for this study was based on the default weights suggested by MS Excel.

This DEA formulation was then run on Microsoft Excel, with the help of the Excel Add-in, Visual Basic for Applications (VBA). The VBA code for the output oriented VRS DEA model was written based on Zhu (2009). The VBA code automated the DEA calculations and this was run 8 times for the 11 banks to compute the efficiency scores.

The efficiency scores so computed were then regressed in the second stage of our analysis, where the Tobit Censored Regression was applied to the efficiency scores of each of the banks to understand how four selected variables may be affecting the efficiency scores of the banks over the years.

The four variables selected were total assets (to indicate bank size), net income (to reflect profitability), market power (to estimate each bank's market share) and total equity (as a proxy for bank capitalization). It must be noted the selection of the explanatory variables was constrained based on the availability of non negative data for the sample banks.

The efficiency scores (from the first stage of our analysis), being the dependent variables, were regressed (second stage of analysis) against the four independent variables to estimate if the efficiency scores were affected by any of these variables and if so, to understand what the relationship between the independent variables and the efficiency score is.

The present study used the Tobit censored regression where the dependent variable (i.e. the efficiency scores) fell between 1 (indicating efficiency) or above 1 (indicating inefficiency). Since the dependent variable in this study fell between limits, the Tobit censored regression model as proposed by Tobin (1958) was appropriate to censor the limits of the dependent variable. The independent variables (or regressors) of the observations which are limited are observed in the regression, unlike the truncated regression model where the observation is considered missing if the dependent variable is greater (or lesser) than a specified limit.

This is also why the ordinary least squares method was not selected as the regression technique. The OLS technique would result in biased regression estimates which are lesser than one, while many datasets in the present study were equal to one.

Maddala (1983) clearly explains how standard multiple regressions are based on an assumption of normal and homoscedastic distribution of dependent variables, while a case of limited dependent variables will not result in expected errors that are equal to zero. In this way, standard regression tests will result in a biased estimate for data sets involving limited dependent variables.

The four selected variables, namely, total assets (TA), net income (NI), market power (MP) and total equity (TE) were used as independent variables and regressed against the efficiency scores using the Tobit censored regression technique based on the following model -

$$\theta = C + \beta 1\, TA + \beta 2\, NI + \beta 3\, MP + \beta 4\, TE$$

Where, θ = Efficiency score;

C = Constant;

$\beta 1$ = Coefficient of TA;

TA = Total assets;

$\beta 2$ = Coefficient of NI;

NI = Net income;

$\beta 3$ = Coefficient of MP;

MP = Market power;

$\beta 4$ = Coefficient of TE;

TE = Total equity.

The Tobit censored regression test was carried out using the Matrixer Econometric Program (version 5.1 beta), which is a software developed by Tsyplakov (2004) for running small and medium scale econometrics and statistical functions for research problems. This software was used for running the Tobit censored regression test.

For the test, the left limit selected was 1, and so all dependent variables which are 1 or below are censored.

The first and second stage results so arrived at have been discussed in the following sections.

4. Empirical Results and Findings

4.1. Data Envelopment Analysis: Stage One Findings

The estimation of technical efficiency scores for 11 local UAE commercial banks over the period of ‘2003-‘2010 using the VRS, output oriented DEA approach with 2 input and 2 output variables gave interesting insights into UAE banks and how their efficiency scores have developed over the pre and post crisis periods.

Table 4.1.1 below presents the efficiency scores of the 11 local UAE commercial banks, over the period of ‘2003-‘2010, as well as the absolute number and percentage of efficient banks in each year. The efficient banks have an efficiency score of 1, while the inefficient banks have efficiency scores greater than 1 and have been highlighted in grey below.

Table 4.1.1 – Technical Efficiency scores of local UAE commercial banks from ‘2003 – ‘2010

Sample Banks	2003	2004	2005	2006	2007	2008	2009	2010
NBAD	1	1	1	1	1	1	1	1
ADCB	1	1	1	1	1	1.06817	1.28888	1.27765
FGB	1.16185	1	1	1	1	1	1	1
Mashreq Bank	1	1.06613	1	1	1	1	1	1
UNB	1.04924	1	1.03575	1.15872	1.07044	1	1.38414	1.35198
CBD	1	1	1	1	1	1	1.08417	1.00874
RAKBank	1.52519	1.38037	1.11597	1	1	1	1	1
BOS	1	1	1	1	1	1	1.03483	1.00824
ABIFT	1.3259	1.45721	1	1.09391	1.26346	1	1	1
CBI	1.38218	1	1.37628	1.86331	1.42974	1.63315	2.25406	2.36471
UAB	1	1	1.32441	1	1	1	1	1
No. of Efficient Banks	6	8	7	8	8	9	6	6
% of Efficient Banks	54.55%	72.73%	63.64%	72.73%	72.73%	81.82%	54.55%	54.55%
Change in % Efficient Banks	N/A	33.33%	-12.5%	14.29%	0.00%	12.50%	-33.3%	0.00%

The pre crisis period for the purpose of the present study is understood to refer to the years ‘2003 to ‘2008. The post crisis period on the other hand, comprises the years ‘2009 to ‘2010.

This demarcation has been made on the basis of the global financial bubble that burst in September ‘2008, whose effects are understood to have been most visible in banking operations from the following year (i.e. ‘2009). Also, year ‘2009 witnessed the Dubai credit crisis in and therefore, the period after ‘2008, i.e. ‘2009 and ‘2010 are considered the post crisis period.

The analysis of the technical efficiency scores of the sample banks has been done by testing the null hypothesizes (H_0) as stated below. The results of each are discussed in the ensuing paragraphs.

I. (i) H_0 = The efficiency scores do not reflect a trend of improving technical efficiency in the pre crisis period.
   (ii) H_1 = The efficiency scores reflect a trend of improving technical efficiency is the pre crisis period.

On studying the efficiency scores presented in table 4.4.1, it can be observed that the absolute number of banks that were efficient in year '2003 were 6 out of the 11 sample banks (i.e. 54.55%), while the number of banks efficient in year '2008 were 9 out of 11 sample banks (i.e. 81.82%).

In this way, there was an increase of 27.27% technically efficient banks over the 6 year period. Further studying the yearly change in the number of efficient banks showed that there has been a consistent positive increase in all the years except for a decline of 12.5% (in '2004 to '2005) and no change in the number of efficient banks from year '2006 to '2007.

Based on these, it can be deduced that the efficiency scores indicate a trend of increasing efficiency in the pre crisis period. Thus, the null hypothesis, H_0 is rejected in this case and the alternative hypothesis, H_1, which states that the efficiency scores reflect a trend of improving technical efficiency in the pre crisis period, is accepted.

This inference is found to be true since the UAE economy was enjoying the building boom from '2003 and banks were part of this dream run, growing exponentially in the pre crisis period, thus paving way for improved technical efficiency scores.

II. (i) H_0 = The efficiency scores do not decline in the post crisis period.
   (ii) H_1 = The efficiency scores decline in the post crisis period.

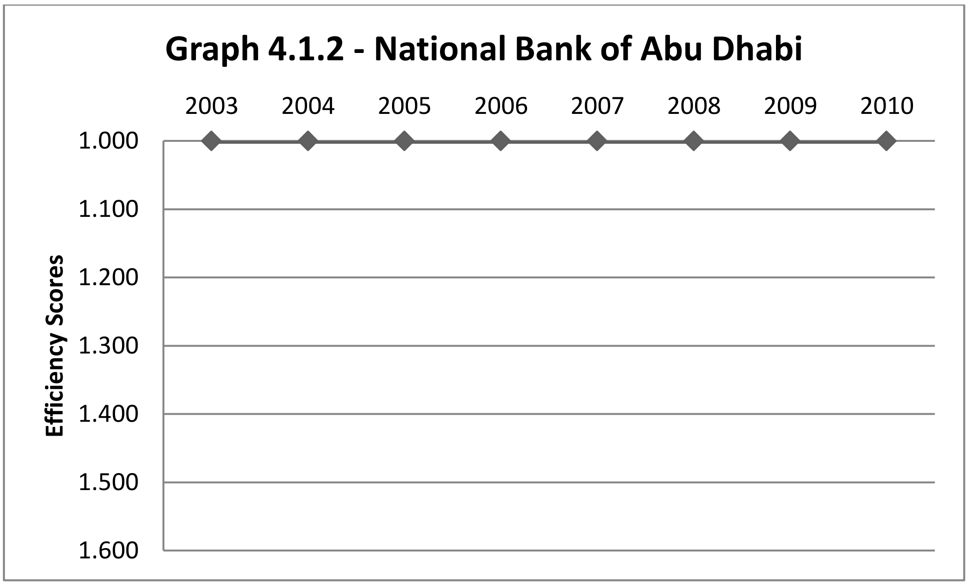
Analyzing the post crisis period, from '2009 to '2010, it can be seen that there was a decrease in the number of efficient banks from 9 (in '2008) to 6 (in '2009), which is a decline of 33.33%. However, no further decline was seen in the number of efficient banks from '2009 to '2010.

In this way, the null hypothesis, H_0 was rejected here and the alternative hypothesis, H_1 was accepted, since the efficiency scores were found to decline in the post crisis period.

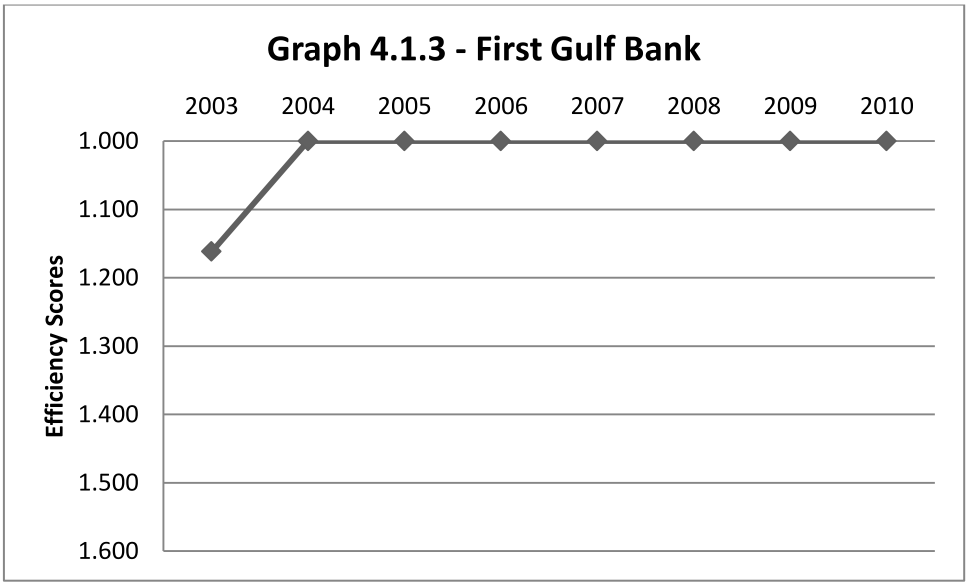
To this end, it can be understood that the sample banks were affected by the crisis of '2008, resulting in a decrease in the number of technically efficient banks in the post crisis period.

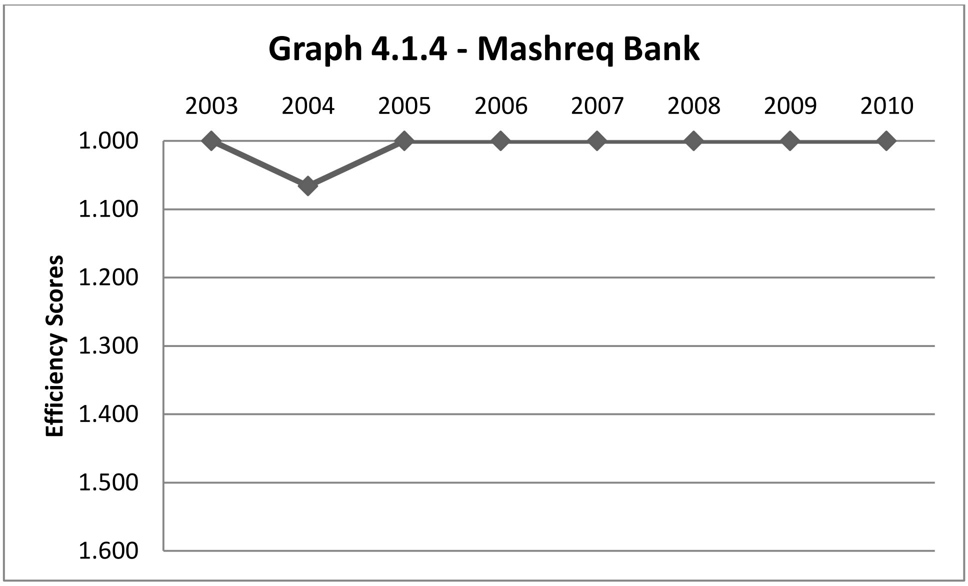
Next, to investigate how the sample banks did on an individual level, the trend of each bank's efficiency score through the sample period was studied and the banks were then ranked accordingly.

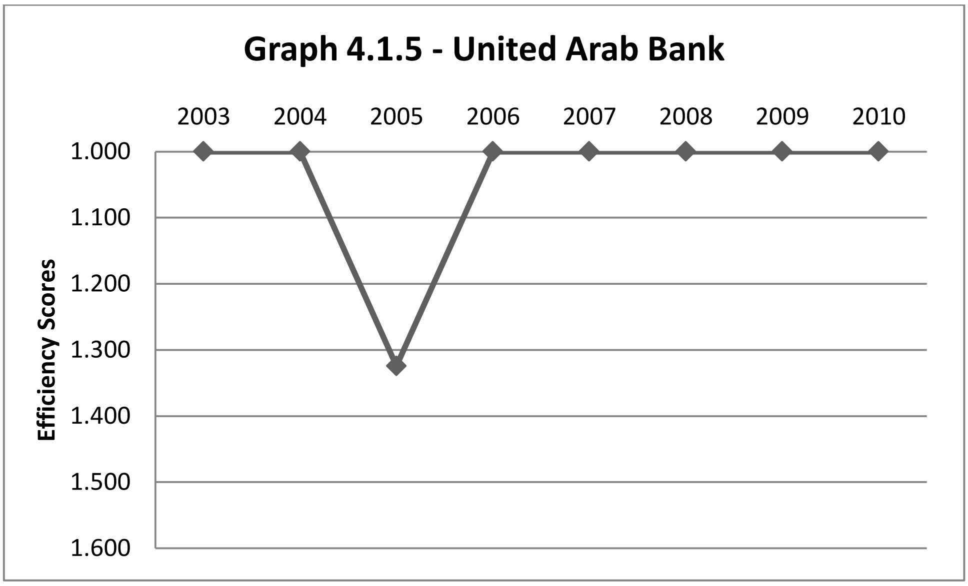
It was noted that the National Bank of Abu Dhabi (NBAD) is the most technically efficient bank amongst the sample banks and is found to be on the efficient frontier throughout the pre and post crisis period (graph 4.1.2).



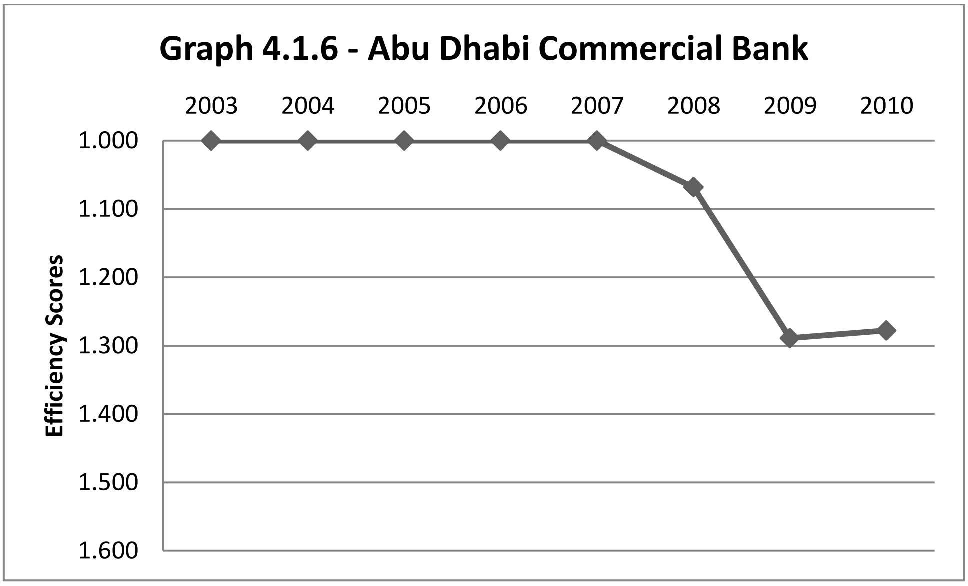
NBAD is followed by the First Gulf Bank (FGB) (graph 4.1.3), Mashreq Bank (graph 4.1.4) and the United Arab Bank (UNB) (graph 4.1.5) which are all found to be technically efficient in 7 out of 8 sample years, although each was found to be inefficient in a different year.



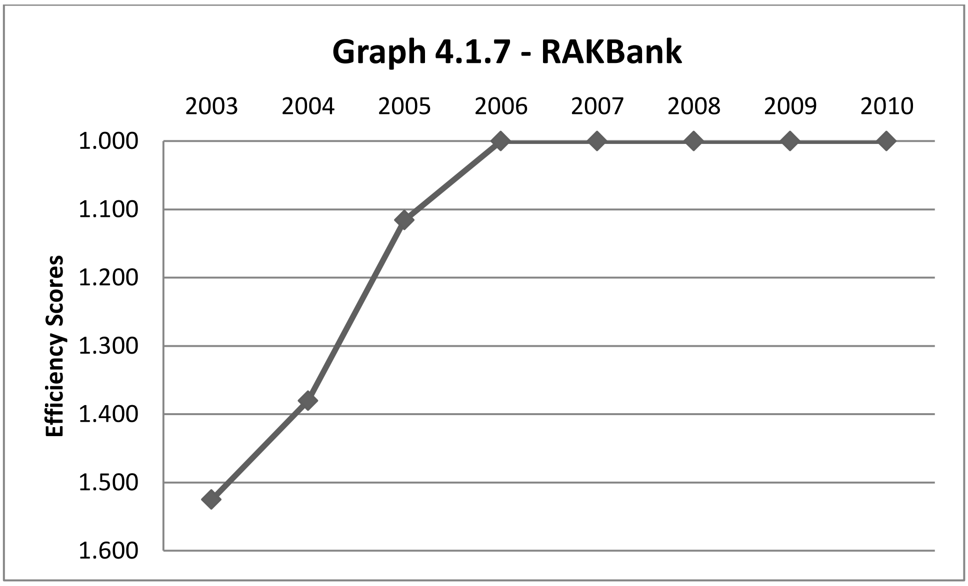




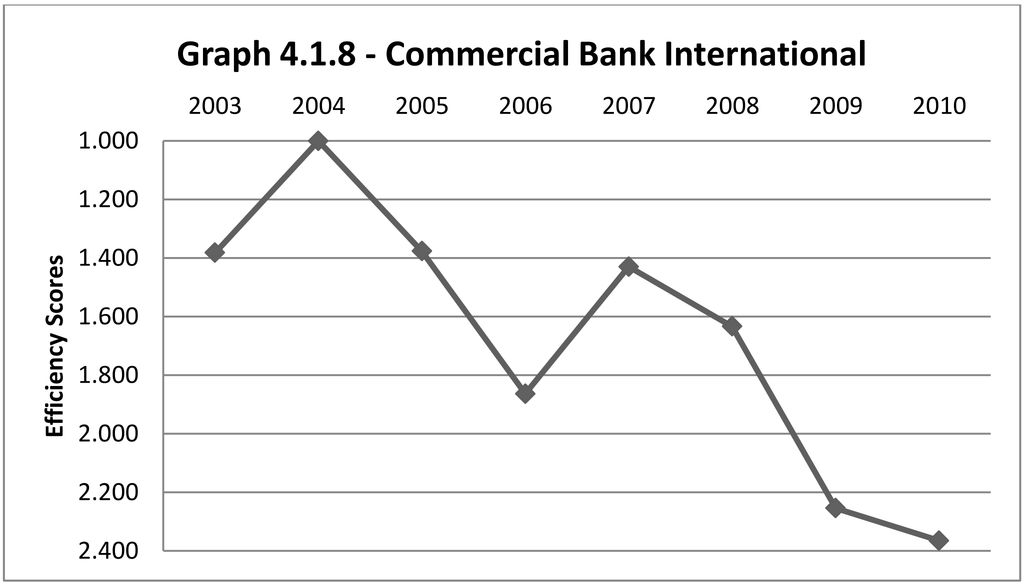
These are followed by the Abu Dhabi Commercial Bank (ADCB), which is also found to be technically efficient in 5 out 8 years (graph 4.1.6). However, it should be noted that ADCB seems to have been affected by the crisis since its efficiency scores reflect a declining trend year ‘2008 onwards.



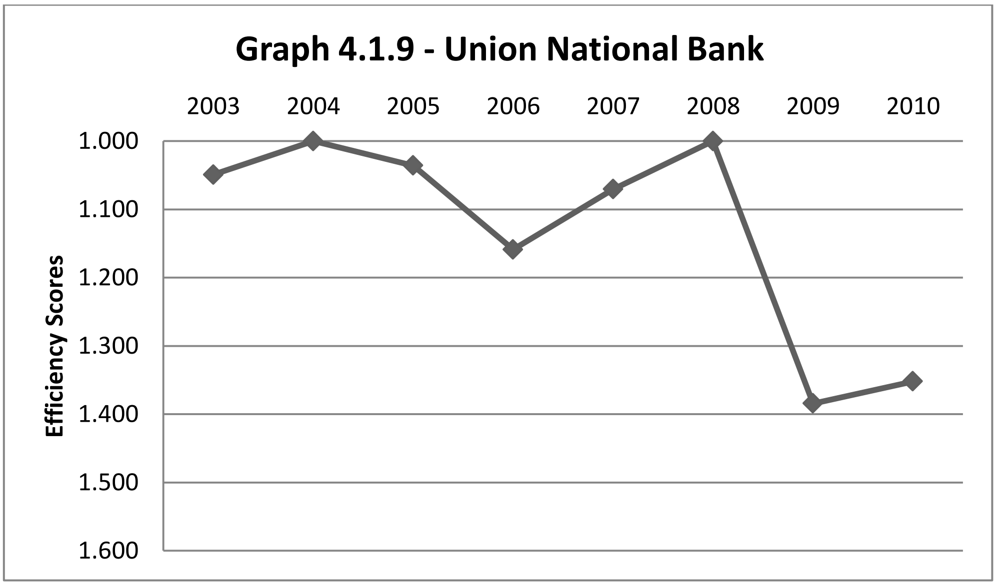
Further, it is interesting to note how, similar to ADCB, RAK Bank has also been efficient in 5 out of 8 years (graph 4.1.7). However, unlike ADCB, RAK Bank showed technically efficient operations in the post crisis period (and inefficiency in the pre crisis period), while ADCB showed opposite trends in the pre and post crisis periods -



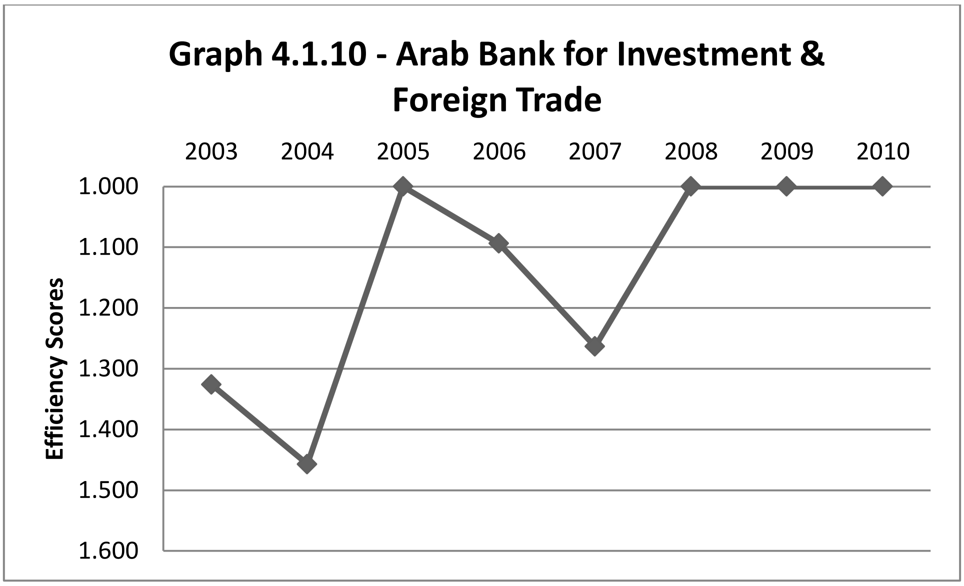
On the flip side, it is observed that the Commercial Bank International (CBI) is the least efficient bank amongst the sample banks, with inefficiency scores for 10 out of 11 sample years (graph 4.1.8). It is also observed that CBI's efficiency scores have been declining right from year '2005, from which an inference can be made that the bank's operations have been inefficient regardless of the impact of the crisis (which would have impacted the operations over and above the existing inefficient operations).



CBI is followed by the Union National Bank (UNB) with inefficiency scores in 6 out of 8 sample years (graph 4.1.9). UNB is noted to have improved its technical efficiency from ‘2006 to ‘2008. However, a steep decline is noted from ‘2008 to ‘2009, indicating the bank was impacted by the crisis.



Based on the efficiency scores, the Arab Bank for Investment and Foreign Trade (ABIFT) is found to be a notch above UNB since it is observed that it is efficient and inefficient in 4 sample years each (graph 4.1.10).



It is interesting to note that while ABIFT was inefficient in the pre crisis period (with the exception of year ‘2005), it has been efficient from year ‘2008 to ‘2010.

To understand variables that may be affecting the efficiency scores of banks, we extend our analysis to the second stage, where the Tobit censored regression is used to understand the effect of 4 explanatory variables on the efficiency scores.

With the second stage of the analysis, the present study aims to be able to answer questions which investigate the reasons behind the banks’ improved (or declining) technical efficiency scores. The next section discusses the findings of the regression test.

4.2. Tobit Censored Regression: Stage Two Findings

For the Tobit censored regression test, the technical efficiency scores computed in stage one of our analysis are regressed against 4 explanatory variables to understand if the selected variables influence the efficiency scores and if so, to what extent.

Hence, the efficiency scores (dependent variable) of the 11 local commercial UAE banks are regressed against 4 independent variables, namely, total assets (TA), net income (NI), market power (MP) and total equity (TE) based on the following model –

$$\theta = C + \beta 1\ TA + \beta 2\ NI + \beta 3\ MP + \beta 4\ TE$$

In the regression test, the left limit for censoring was chosen as 1 and therefore all values at or below 1 were censored.

This model is run for the 11 banks for 3 sample years, which are ‘2003, ‘2009 and ‘2010. The regression test was not applied to the interim years because the percentage of unlimited observations was lesser than 45% in each of these years and the test would then result in a biased estimate. This is similar to Budd and Budd (2006), where the Tobit regression test was applied only to year ‘2004, due to the lack of reliable data for the remaining sample years from ‘1998-‘2003.

The results of the 3 years on which the Tobit censored regression is applied is presented in tables and analyzed thereafter.

The null and alternative hypothesis for this stage of the analysis was tested to investigate if the efficiency scores are found to be influenced by the 4 selected independent variables.

Thus, H0 = The efficiency scores are not dependent on the independent variables total assets, net income, market power and total equity and H1 = The efficiency scores are dependent on the independent variables total assets, net income, market power and total equity.

Table 4.2.1 below presents the results of the Tobit censored regression test for year '2003. The dependent variables in the test are the efficiency scores and the number of observations (11 as can be noted in the table) refers to the total number of observations in which the independent and dependent variables are available (or non missing).

The coefficient of total assets is 0.0005, which means that for an increase in the efficiency scores by 1%, the total assets of the banks need to increase by 0.0005 points (or 0.05%) and vice versa. However, this is not statistically significant since the significance is 0.6339 which is greater than 0.05.

Similarly, market share and total equity are also positively related to the efficiency scores. That is, if market share (which is the ratio of an individual bank's deposits over the total deposits of all banks) and total equity increase by 0.5739 and 0.0009 points respectively, then efficiency scores will also increase by 1%. These are also not significant at the 5% significance level.

However, profitability (which is the log of net income), is found to be negatively related to efficiency of banks and this relationship is also not statistically significant.

Thus, the null hypothesis, H_0 is accepted for year '2003 for all the independent variables, namely total assets, profitability, market share and total equity, indicating that efficiency scores are not dependent on these variables in '2003.

Table 4.2.1 - Tobit Censored Regression '2003

Dependent variable: EfficiencyScores03
Number of observations: 11
Left limit: 1.

Variable	Coefficient	St. Error	t-statistic	Sign.
Constant	1.4798	0.2908	5.0894	0.0038
TotalAssets03	0.0005	0.0011	0.5067	0.6339
Profitability03	-0.0038	0.0038	-0.9893	0.3679
MarketShare03	0.5739	1.3184	0.4353	0.6815
TotalEquity03	0.0009	0.0013	0.7326	0.4967

Number of left-censored observations: 6 (54.54%)
Number of uncensored observations: 5 (45.45%)

Analyzing table 4.2.2 for the regression results in ‘2009, it is seen that total assets, profitability, market share and total equity are positively related to efficiency scores. The relationship between total assets and efficiency scores is significant at the 10% significance level, profitability and market share are positively related to efficiency scores at the 5% significance level, followed by total equity which is not statistically significant.

Therefore, the null hypothesis, H_0 is rejected for total assets, profitability and market share for year ‘2009 while the null hypothesis is accepted for total equity. The alternative hypothesis, H_1 is hence accepted for total assets, profitability and market share and their influence on the dependent variable for year ‘2009.

Table 4.2.2 - Tobit Censored Regression '2009

Dependent variable: EfficiencyScores09
Number of observations: 11
Left limit: 1.

Variable	Coefficient	St. Error	t-statistic	Sign.
Constant	1.2277	0.3378	3.6342	0.0150
TotalAssets09	0.0002	0.0001	2.5537	0.0510
Profitability09	0.0035	0.0012	2.9272	0.0327
MarketShare09	1.5681	0.5757	2.7238	0.0416
TotalEquity09	0.0006	0.0003	1.9395	0.1101

Number of left-censored observations: 6 (54.54%)
Number of uncensored observations: 5 (45.45%)

In table 4.2.3 below, it is noted that the coefficients of total assets, profitability and market share are positive, which means an increase in total assets and profitability for sample banks in ‘2010 results in a 1% increase in the efficiency scores. This result is statistically significant at the 5% significance level for total assets and at the 1% significance level for profitability and market share.

Therefore, the null hypothesis, H_0 is rejected and the alternative hypothesis, H_1 for the relationship between efficiency scores with total assets, profitability and market share is accepted.

Further, total equity is observed to be negatively related to efficiency scores. This relationship is statistically significant at the 5% significance level.

Therefore, the null hypothesis is rejected for all the independent variables and the alternative hypothesis, H_1 is accepted for year ‘2010.

Table 4.2.3 - Tobit Censored Regression '2010

Dependent variable: EfficiencyScores10
Number of observations: 11
Left limit: 1.

Variable	Coefficient	St. Error	t-statistic	Sign.
Constant	1.9673	0.2232	8.8129	0.0003
TotalAssets10	0.0002	0.0000	3.7373	0.0135
Profitability10	0.0027	0.0006	4.3004	0.0077
MarketShare10	1.8982	0.4463	4.2528	0.0081
TotalEquity10	-0.0003	0.0001	-2.6871	0.0434

Number of left-censored observations: 6 (54.54%)
Number of uncensored observations: 5 (45.45%)

Based on the above results, it can be concluded that the size of a bank (indicated by total assets) affects the technical efficiency scores of the sample banks in the post crisis period, since this relationship is statistically significant in ‘2009 and ‘2010. In this way, larger banks reflect higher levels of technical efficiency in their operations in the post crisis climate.

Similar results of a positive relationship between bank size and efficiency scores have been found in previous studies by Mester (1996), Altunbas, Liu, Molyneux, and Seth (2000), Jemric and Vujcic (2002) and Yildirim (2002). However, Isik and Hassan (2000) and Darrat, Topuz and Yousef (2002) arrived at results, for Turkish and Kuwaiti banks, respectively which were contrary to the findings of the present study.

Bank size may be positively influencing efficiency scores due to different reasons, such as economies of scale, pooling of technological know how and resources amongst branches of such large banks, better flexibility in financial markets as well as an ability of diversifying (or spreading) credit risk more appropriately (Cole & Gunther 1995).

Similarly, profitability, indicated by the log of net income, is found to be positively related to banking efficiency in the post crisis period. This is consistent with the results of Yildirim (2002) and Casu and Molyneux (2003), but contrary to the findings of Limam (2001) who deduced a weak link between profitability and technical efficiency for GCC banks in ‘1999.

A higher bank net income would mean that a bank is able to cover its costs into higher revenues effectively. To realize a higher net income, a bank would be using its limited resources efficiently, thereby resulting in improved technical efficiency scores.

Further, market share, represented by the ratio of an individual bank’s deposits to total deposits is found have a positive relationship with the efficiency of banks. This means that banks which are able to capture a larger portion of the market are expected to be more technically efficient.

It can then be understood that market leadership for banks translates to increased efficiency. This view has been supported by the findings of Budd and Budd (2006) for UAE banks from ‘1998-‘2004.

Lastly, total equity which is the proxy for capitalization in the present study is noted to have a positive influence on the dependent variable in ‘2009, which is not statistically significant, while a negative influence on efficiency scores in the pre crisis period, statistically significant at the 5% significance level.

Thus, if a bank’s capitalization ratio is higher, its efficiency score will be lower and vice versa. Similar findings were put forward by Berger and Mester (1997) and Budd and Budd (2006). However, these are in contrast to the results arrived at by Darrat, Topuz and Yousef (2002).

5. Conclusion

The UAE is one of the fastest growing economies in the world, with its economy growing at a phenomenal rate in the past decade. This economic boom meant its banking sector had to keep up to sustain the accelerated growth and by this way, became one of the most important financial hubs in the Middle East.

However, given the lack of publicly available reliable financial data, the study and analysis of the UAE banking sector has been limited, although growing. This study was thus, a step in this direction and took on to analyze the technical efficiency of the banking sector in UAE, with a focus on the pre and post crisis period.

Efficiency and the study of its parameters has become a significant area of research and more so in the post crisis period, given the volatility and risk-averse attitude that banks have to adhere to, to ensure stability of operations.

To this end, it was hoped the research would throw light on how the UAE banking sector was performing prior to the global financial crisis and if the sector was affected by the crisis that hit in ‘2008.

The present study analyzed a sample set of 11 local commercial UAE banks, from the period of ‘2003-‘2010, where the period ‘2003-‘2008 was demarcated as the pre crisis period and ‘2009-‘2010 as the post crisis period.

The technique of Data Envelopment Analysis (DEA) was used to estimate the technical efficiency scores of banks through the sample period, with the help of 2 input and 2 output variables that were selected.

Based on the set of sample banks and their technical efficiency scores, it was found that the National Bank of Abu Dhabi has been consistently technically efficiency through the pre and post crisis, followed by the First Gulf Bank , Mashreq Bank and the United Arab Bank which were all efficient in 7 of the 8 sample years.

The trend of efficiency scores from ‘2003-‘2010 also gave interesting insights into how the UAE banking sector was developing in the pre and post crisis period. The pre crisis period (i.e. ‘2003-‘2008) saw an average increase in efficiency scores by 27.27% and a positive increase of 12.5% in the number of technically efficiency banks was noted in all years except in ‘2004.

This can be explained by the economic boom of the UAE that began in the early years of the ‘2000 decade when the government allowed foreign players to own real estate in Dubai. The property prices then sky rocketed, with the prices peaking in ‘2008. Real estate had then become the driver of economic growth, and the UAE banking sector being intrinsically related to the real estate market, grew exponentially as well. This trend is evident in the pre crisis efficiency scores which were computed.

However, when the heavily indebted Dubai World announced that it would be unable to repay $25 billions of its debts, a credit crisis was triggered in Dubai, causing injury to the already fragile global financial system.

This affected the UAE banks, since liquidity had dried up and banks which had loaned to Dubai corporations were forced to curtail operations and safeguards assets. These events brought down efficiency scores as the number of technically efficient banks dropped by 33.33% from ‘2008-‘2009. However, there was no change in the number of technically efficient banks from ‘2009-‘2010.

In this way, it can be concluded that a sharp decline of efficiencies were observed in ‘2009, and banks were conservative and playing safe to avoid any further dips, thereby bringing about no more further decline in efficiency scores in ‘2010.

Further, the efficiency scores that were computed in the first stage of the analysis were used in the second stage of the analysis, where the Tobit censored regression test was used to regress the dependent variables (the efficiency scores) against 4 selected independent variables, to understand if the independent variables have any influence on the efficiency scores of banks.

The evidence gathered as per the regression test indicated that bank size (measured by the log of total assets) is an influencing factor into how efficient a bank’s operations are. That is, larger the bank, better the efficiency score.

It was also observed that profitability or a higher net income also results in improved efficiency. However, a caveat as highlighted by Budd and Budd (2006) suggests that profitability cannot be wholly credited for improved levels of efficiency. The authors state that it is not profitability alone but the ability of banks to sustain efficient operations in the current globally challenging times that will result in higher levels of efficiencies.

The share of UAE banks in the market as well as total equity (or bank capitalization) were also found to be influencing factors when it came to efficiency of banks. It was noted that banks which are able to capture larger chunks of the market perform more efficiently while banks with lower levels of capitalization have higher levels of efficiency.

It must be noted that the present study suffered some limitations in the form of availability of reliable, accurate and uniform financial data for UAE banks. This limited the data set that was used for the analysis, however, the application of DEA, the Tobit censored regression test and its results are a good indication of how the UAE banking sector behaved in the pre and post crisis period.

Future research can focus on using larger data sets as well as longer sample periods to provide more insight into efficiency scores. The use and comparison of parametric and non parametric methods, i.e. SFA and DEA is another area which can be used to better understand the drivers of banking efficiency.

In conclusion, given Dubai's prudent approach to rationalizing its finances, the recent closing in of the budget deficit gap and to some extent, the signs of lesser dependency on the real estate market, it can be understood that investor confidence is improving and the UAE banking sector will be reflecting these trends. Hence, based on lessons learnt from the crisis, in days to come, it is expected that the UAE banking sector will be doing better.

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Appendix 1) – Descriptive Statistics of sample UAE banks from '2003-'2010

		Input Variables		Output Variables	
Year	Descriptive Statistics	Interest Expense	Non Interest Expense	Net Interest Income	Non Interest Income
2003	Mean	161,863,636	183,036,364	342,663,636	184,172,727
	Standard Deviation	202,965,171	157,561,799	289,457,570	205,137,959
	Minimum	22,200,000	36,900,000	80,700,000	41,800,000
	Maximum	647,700,000	518,600,000	772,900,000	658,100,000
2004	Mean	288,854,545	185,154,545	417,836,364	243,809,091
	Standard Deviation	367,504,681	137,725,679	346,499,395	216,057,499
	Minimum	31,200,000	40,200,000	85,800,000	50,800,000
	Maximum	1,012,600,000	487,800,000	1,010,900,000	722,100,000
2005	Mean	633,672,727	294,609,091	635,654,545	746,781,818
	Standard Deviation	668,424,952	242,236,795	540,136,565	691,432,952
	Minimum	79,000,000	63,000,000	136,300,000	71,900,000
	Maximum	2,175,500,000	777,000,000	1,678,100,000	2,102,400,000
2006	Mean	1,104,409,091	399,863,636	778,181,818	595,836,364
	Standard Deviation	1,127,773,226	308,465,652	656,856,048	604,011,272
	Minimum	100,000,000	64,300,000	174,700,000	70,600,000
	Maximum	3,436,800,000	1,031,400,000	2,022,900,000	1,944,900,000
2007	Mean	1,548,427,273	538,027,273	976,736,364	818,754,545
	Standard Deviation	1,620,238,549	444,229,412	792,427,538	800,675,756
	Minimum	114,200,000	86,300,000	223,700,000	107,900,000
	Maximum	4,679,200,000	1,409,800,000	2,406,500,000	2,649,900,000
2008	Mean	1,560,181,818	870,290,909	1,574,163,636	834,309,091
	Standard Deviation	1,529,869,775	625,447,863	1,161,732,214	684,627,810
	Minimum	119,100,000	130,400,000	273,600,000	115,700,000
	Maximum	3,775,600,000	1,874,000,000	3,613,500,000	1,877,500,000
2009	Mean	1,450,581,818	819,709,091	1,796,236,364	918,536,364
	Standard Deviation	1,309,481,436	667,124,142	1,488,958,671	933,728,664
	Minimum	97,300,000	138,500,000	324,500,000	135,500,000
	Maximum	3,621,700,000	1,935,900,000	4,574,200,000	2,643,700,000
2010	Mean	1,284,881,818	889,772,727	2,009,500,000	874,709,091
	Standard Deviation	1,185,411,301	732,083,128	1,709,878,324	782,214,680
	Minimum	68,800,000	152,000,000	343,300,000	113,100,000
	Maximum	3,694,300,000	2,263,000,000	5,251,100,000	2,085,600,000