# DATA ENVELOPMENT ANALYSIS: A TOOL FOR MONITORING THE RELATIVE EFFICIENCY OF LEBANESE BANKS

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Abstract

*This paper implements a Data Envelopment Analysis (DEA) approach to measure the relative performance of Lebanese banks over an 8-year period (1997 to 2004). It also demonstrates DEA as an effective monitoring tool for central banks to track banks' efficiencies to maintain a sustainable growing sector and to provide early warning signals for a potentially at risk bank. DEA input and output parameters are identified for the Lebanese banking sector as an intermediary player between savers and investors. For each bank, a DEA efficiency score is computed, decomposed into technical and scale efficiencies, and tracked on a yearly basis. During the period of this study, some banks failed and closed, and some merged and acquisitioned, hence characteristics of failed and merged banks are investigated with a close attention to their technical efficiency patterns. We conclude with a positive recommendation on the usage of DEA and highlight future research directions.*

*Keywords: Data Envelopment Analysis, Lebanese Banks, Efficiency, Bank Failure.*

## 1 INTRODUCTION

Lebanese economy is mainly based on the provision of services where, the financial and banking sector plays a major role cultivated by the region's economic market growth. Lebanon has a relatively liberalized banking sector and has thrived in the Arab world. In the 8-year period, starting from 1997 to 2004, the Lebanese Banking Sector (LBS) has seen *five-bank* closures and *nine-bank* mergers and acquisitions. Mergers and acquisitions have increased due to the banking industry's movement away from small-family owned businesses to large-corporate rivals competing to increase market share. The Lebanese Central Bank (Banque Du Liban, BDL) cooperates with the Banking Control Commission (BCC) in supervising the operations of Lebanese banks. Originally, the banking supervision was carried out by the department of control within BDL. However in 1967, BCC was created as an independent body with a large authority over the supervision of banks. It carries out its supervision through off-site examination and on-site examination. The off-site examination allows BCC to identify early warning signals for bank failure through the analysis of financial statements and statistical reports that banks submit to BDL. Such an analysis is based on tracking of single-input to single-output ratios within the traditional control mechanism of CAMEL: Capital adequacy, Asset quality, Management efficiency, and Earning and Liquidity.

Hence, it is of great interest to develop a new alternative and effective control mechanism for managing, monitoring and controlling the most important sector of the Lebanese economy. In this paper, we propose such a mechanism based on a non-parametric frontier analysis approach, Data Envelopment Analysis (DEA), to investigate both the technical and scale efficiencies of LBS over the previously mentioned 8-year period. In this DEA approach, each bank is considered as a Decision Making Unit (DMU) which transfers multiple inputs to produce multiple outputs. It then defines a relative efficiency score for each DMU by comparing its multiple-input and multiple-output to the *best frontier* performers among all other DMUs, as opposed to traditional performance methods such as CAMEL, and regression analyses which compares efficiencies to the *average central tendency* performance. It should be noted that this study presents the first contribution to investigate the usage of DEA to measure the perfomance of the LBS.

The remaining part of the paper is organised as follows. First, a brief on DEA background, models and efficiencies; DEA applications to the regional banking sectors; and DEA implementation to LBS are presented. Second, the DEA results are discussed in terms of technical efficiency (TE) and scale efficiency (SE) scores to produce ranking of LBS, and to investigate the performance trends after the occurrence of mergers and acquisitions. Finally, the DEA analysis is demonstrated as an effective warning tool for detecting bank failures that can be used by BCC of Lebanon, followed by a conclusion and further research directions.

## 2 DATA ENVELOPMENT ANALYSIS

### 2.1 DEA brief background and applications to banking sectors

DEA was first proposed by Charnes *et al*. (1978), and is a non-parametric method of efficiency analysis for comparing units relative to their best peers (efficient frontier) rather than average performers, and to identify benchmarks for inefficient units. It does not require any assumption on the shape of the DMUs frontier surface and it makes simultaneous use of multiple inputs and multiple outputs. DEA defines the relative efficiency for each DMU (bank branches, hospitals, schools) by comparing the DMU's inputs and outputs to other DMUs data in the same ''cultural or working'' environment. The outcomes of a DEA study includes: *i*) A piecewise linear empirical envelopment frontier surface of the best practice , consisting of DMUs exhibiting the highest attainable outputs for their given level of inputs; *ii*) An efficiency metric (score) to represent the maximal performance measure for each DMU measured by its distance to the frontier surface; iii) Efficient projections onto the efficient frontier with identification of an efficient reference set consisting of the "close " efficient DMUs for benchmarking and improving each inefficient unit; i*v*) a ranking of units from best (highest score) to worst (lowest score).

There are basically two types of DEA models: Charnes *et al*. (1978) introduced the constant *returns-to-scale* (CRS) and Banker *et al.* (1984) introduced the *variable returns-to-scale* (VRS) model. DEA models are also classified *as input-oriented, output-oriented or additive* (both inputs and outputs are optimized in the best interest of the evaluated unit) based on the direction of the projection of the inefficient unit onto the frontier surface. In the present study, DEA *input-oriented* models are chosen because the cost minimization (or reduction) is considered for a given bank's operation. Based on Zhu (2004), the following mathematical formulation of an input-oriented DEA model where the inputs are minimized and the outputs are kept at their current level is presented:

$$\Theta^* = \text{Min } \theta, \text{ Subject to: } \sum_{j=1}^{n} \lambda_j x_{ij} \le \theta x_{i0} \; i = 1, 2 \ldots, m; \quad \sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{r0} \; r = 1, 2 \ldots, s \quad (1)$$

$$\sum_{j=1}^{n} \lambda_j = 1 \text{ and } \lambda_j \ge 0 \; j = 1, 2 \ldots, n \quad (2)$$

Where $DMU_0$ represents one of the *n* DMUs under evaluation, $x_{i0}$ and $y_{r0}$ are the amount of the *i*th input and *r*th output for $DMU_0$ , respectively and m and s are the numbers of inputs and outputs, respectively. Furthermore, let $s_{i*}$ and $s_{r*}$ be the optimal slack and excess values for each of the two constraints in (1), respectively. $DMU_0$ is said to be *efficient if and only* if $\Theta^*= 1$, and $s_{i*} = s_{r*} =0$ for all *i* and *r;* and it is *weakly efficient* if $\Theta^*= 1$, and $s_{i*} \neq 0$ and (or) $s_{r*} \neq 0$ for some *i* and *r*. The current input levels of an efficient unit cannot be reduced indicating that $DMU_0$ is on the frontier surface. Otherwise, when $\Theta^*< 1$, $DMU_0$ is *inefficient* and is dominated by the frontier of best performing units, i.e. it can either increase its output level or decrease its input levels by projection onto the efficient surface which identifies corresponding benchmarks. $\Theta^*$ represents the input-oriented efficiency score of $DMU_0$. The mathematical formulation in (1) and (2) represents the input-oriented VRS model whereas the formulation in (1) excluding (2) defines the input-oriented CRS model. From the efficiency scores of both CRS and VRS models, one can easily obtain the relative *technical efficiency* (TE) scores, *pure technical efficiency* (PTE) and *scale efficiency* (SE). TE efficiency score obtained from the CRS model is called *global* efficiency*;* while the PTE obtained from the VRS model is called the *local* pure technical efficiency (*or weakly efficient*). If a DMU is fully PTE efficient (100%), but has a low TE score, then it is locally efficient but not globally efficient due to the scale size of the DMU. Hence, the scale efficiency (SE) is characterised by the ratio of the two scores, i.e. TE = PTE × SE. According to Dyson *et al*. (2001), the number of DMUs should be at least twice the number of inputs and outputs to allow DEA to produce a decent level of discrimination:

$$n \ge 2 \times m \times s \quad (3)$$

DEA applications on the European and Mediterranean banking industry include but not limited to: Mostafa (2007), Al-Muharrami (2007) and Ramanathan (2007) on Gulf Cooperation Council banks; Halkos and Salamouris (2004), and Athanassopoulos and Giokas (2000) on Greek commercial banks, Tortosa_Ausina *et al*. (2008) on Spanish saving banks, Mercan *et al*. (2003) on Turkish banks, Havrylchyk (2006) on Polish banks, and Camanho and Dyson (2006) on Portuguese banks. For comprehensive bibliographies on DEA, we refer to Gattoufi *et al* (2004) and for more details on theory and application we refer to Cooper *et al.* (2006) and Zhu (2004).

## 2.2 Lebanese Banking Sector DEA Implementation

The information about the Lebanese banks is taken from the annual balance sheets that are reported in BILANBANQUES published books in Baz (1999-2005). It should be noted that not all banks were operational in a specific year. Hence, banks with incomplete balance sheets are eliminated from the study. In addition, investment banks that are consolidated into the mother bank's balance sheet are also removed. Islamic banks are excluded from the study since their activities differ from other commercial banks (e.g. they do not handle earned or paid interest). The number of banks varies from one year to the next during the 8-year period dropping from 60 in 1997 to 45 in 2004 due to bank failures and mergers and acquisitions, but the number still satisfies equation (3). The 60 Lebanese banks are further classified into four different groups (G) according to their total deposits: *Alpha group* (α) includes 14 banks with deposits over 1 Billion USD; *Beta group* (β) includes 17 banks with deposits between 300 Million and 1 Billion USD; *Gamma group* (γ) includes 12 banks with deposits between 100 and 300 Million USD and *Delta group* (δ) includes 17 banks with deposits under 100 Million USD.

The inputs and outputs in DEA represent the activities and role of a bank. According to Das and Ghosh (2005), the *production approach* views banks as providers of services to customers, thus possible inputs may include labour, material, space, information systems and possible outputs may include number of transactions, documents processed or number of deposits and loan accounts. The *intermediate approach* views a bank as an intermediary of funds between savers and investors so possible inputs may include general expenses, interest expenses and deposits, whereas possible outputs may include assets, loans and income. In Osman, Hitti and Al-Ayoubi (2008), we have reviewed most of the world literature on DEA performance in the banking sector, due to space limitation, we shall only provide here the main findings and the reader is advised to refer to the original paper. It was found that the intermediate approach is most frequently used approach. Moreover, the associated inputs and outputs are represented in Table 1 with our addition of the number of branches. The new addition would capture the size and working environment of a bank, the more branches a bank has the greater is the accessibility to customers.

| | |
|---|---|
| **DEA Inputs:** | Interest expenses, General expenses; Total deposits; Number of employees, and number of branches. |
| **DEA Outputs:** | Interest income; Non-interest income; and Total loans. |

*Table 1. DEA Inputs and Outputs for Measuring Bank's Performance*

When applying DEA, it is assumed that the inputs fully represent all the used resources and the outputs describe all the produced activities by the DMUs . The DEA inputs and outputs must also be isotonic (the less input and the larger the output are better) .

## 3 DEA RESULTS & ANALYSIS

In this section, we analyse the empirical findings on the main points previously outlined. The DEA results are provided in the following sub-sections where the technical efficiencies (TE), Banks' rankings, impact of mergers and failures are provided with statistical yearly indicators of averages of efficiencies and standard deviations over the eight year period (1997-2004) for each bank. It should be noted that the basic results are generated from the Microsoft Excel DEA Solver-Add-in provided in Zhu (2004).

### 3.1 Technical Efficiencies Analysis and Bank Rankings

The TE score of a bank reflects its success/failure in efficiently transforming inputs into outputs. This assessment requires a standard benchmark of performance against which the success/failure is measured. The input-oriented DEA model provides an empirical estimate (the so-called efficient frontier surface) for such standard based on the available set of evaluated banks; hence it is called a relative measure. Table 2 provides TE results in columns 3 to 8, overall TE averages in column 9, their TE ranks in 10, for all the LBS named in column 1 and with each corresponding classification group (G) in column 2. Please note that the last column contains each individual's bank PTE averages over the same 8-year period. The TE results show decreasing trends for some banks, leading to closure of low efficiency banks (such as the Jordan National Bank, the United Credit Bank and Inaash Bank) or mergers between low (L) and high (H) efficiency banks (e.g. Allied Bank (L) and Bank de la Mediterrannee (H); Wedge Bank Middle East (L) and ABN AMRO bank (L) with Byblos Bank (relatively H); United Bank of Saudi and Lebanon (L) and Fansabank (relatively H) with Banque de la Bekaa (H). Moreover, looking at the 100% TE efficient banks, they are 9 out of 60 (representing 15% of the total banks) out of which 75% of the TE banks are belonging to $\delta$ and $\gamma$ groups of smaller-sized banks, and none of them belongs to the $\alpha$ large-sized banks, i.e. smaller banks tend to transform their

inputs into outputs more effectively then larger banks. It can also be seen from the last column that the local PTE average scores of each bank increase due to scale efficiency with an overall increase from an average of TE at 70% to 85% for PTE average. The total number of weakly efficient PTE banks is

| **CRS Input-Oriented Model - Year** | | **97** | **98** | **99** | **00** | **01** | **02** | **03** | **04** | **Av.** | Bank | Av. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bank Name** | **G** | **TE** | **TE** | **TE** | **TE** | **TE** | **TE** | **TE** | **TE** | **TE** | **Rank** | **PTE** |
| Banque de l'Habitat | γ | - | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 1 | 100 |
| Banque Nationale de Paris | β | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | **100** | 1 | **100** |
| BCP Oriel Bank | γ | - | 100 | - | - | - | - | - | - | **100** | 1 | **100** |
| Citibank | δ | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | **100** | 1 | **100** |
| Crédit Lyonnais Liban | δ | 100 | 100 | 100 | 100 | 100 | - | - | - | **100** | 1 | **100** |
| North Africa Commercial Bank | β | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | **100** | 1 | **100** |
| Saudi National Commercial Bank | γ | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | **100** | 1 | **100** |
| The Syrian Lebanese Commerical Bank | δ | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | **100** | 1 | **100** |
| Banque Saradar | α | 98 | 100 | 100 | 100 | 100 | 100 | 100 | - | **100** | 9 | **100** |
| Banque Libano-Française | α | 97 | 95 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 10 | **100** |
| Banque de la Mediterrannée | α | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 90 | 99 | 11 | **100** |
| Rafidain Bank | γ | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 86 | 98 | 12 | **100** |
| HSBC Bank Middle East | β | 100 | 100 | 98 | 88 | 99 | 100 | 100 | 100 | 98 | 13 | **100** |
| Banque du Liban et d'Outre-Mer | α | 93 | 92 | 97 | 100 | 100 | 100 | 100 | 100 | 98 | 14 | **100** |
| ABN AMRO Bank | β | 100 | 95 | 94 | 90 | 94 | - | - | - | 95 | 15 | 98 |
| Bank of Beirut | α | 91 | 100 | 75 | 92 | 93 | 80 | 100 | 100 | 91 | 16 | 99 |
| Fransabank | α | 97 | 82 | 93 | 92 | 88 | 78 | 91 | 81 | 88 | 17 | **100** |
| Finance Bank | δ | 100 | 100 | 62 | 67 | 70 | 100 | 100 | 100 | 87 | 18 | 94 |
| Byblos Bank | α | 100 | 85 | 83 | 84 | 80 | 70 | 91 | 89 | 85 | 19 | **100** |
| Lebanon and Gulf Bank | β | 80 | 82 | 99 | 86 | 83 | 75 | 100 | 76 | 85 | 20 | 94 |
| Banque Audi | α | 92 | 80 | 78 | 79 | 78 | 80 | 95 | 92 | 84 | 21 | **100** |
| Banque de la Békaa | δ | 72 | 57 | 73 | 89 | 100 | 100 | - | - | 82 | 22 | 91 |
| United Bank of Saudi and Lebanon | δ | 90 | 89 | 66 | - | - | - | - | - | 82 | 23 | 91 |
| Bank of Beirut and the Arab Countries | α | 84 | 74 | 73 | 92 | 79 | 65 | 86 | 62 | 77 | 24 | 93 |
| Société Générale de Banque au Liban | β | 94 | 77 | 72 | 100 | 69 | 66 | 71 | 62 | 76 | 25 | 99 |
| Beirut Riyad bank | β | 89 | 76 | 61 | - | - | - | - | - | 76 | 26 | 92 |
| Al-Mawarid Bank | β | 52 | 46 | 66 | 73 | 68 | 100 | 100 | 100 | 76 | 27 | 87 |
| Banque Européenne pour le Moyen-Orient | β | 76 | 70 | 66 | 83 | 70 | 74 | 79 | 68 | 73 | 28 | 87 |
| Lebanese Swiss Bank | β | 75 | 49 | 62 | 100 | 80 | 47 | 93 | 69 | 72 | 29 | 85 |
| Arab Bank | α | 89 | 82 | 77 | 74 | 69 | 74 | 49 | 55 | 71 | 30 | 92 |
| Habib Bank | γ | 100 | 57 | 60 | 85 | 68 | 58 | 65 | 69 | 70 | 31 | **100** |
| Crédit Libanais | α | 77 | 66 | 73 | 73 | 63 | 63 | 75 | 67 | 70 | 32 | 98 |
| Lebanese Canadian Bank | α | 73 | 47 | 54 | 60 | 56 | 57 | 100 | 90 | 67 | 33 | 84 |
| Intercontinental Bank of Lebanon | α | 82 | 38 | 40 | 54 | 55 | 65 | 100 | 100 | 67 | 34 | 84 |
| Middle East and Africa Bank | δ | 72 | 50 | 72 | 59 | 54 | 54 | 68 | 72 | 63 | 35 | 79 |
| Banca di Roma | γ | 71 | 38 | 31 | 100 | 45 | 64 | 82 | 55 | 61 | 36 | 78 |
| Banque Misr Liban | β | 89 | 59 | 65 | 52 | 51 | 48 | 69 | 54 | 61 | 37 | 82 |
| Bank Al-Madina | β | 66 | 28 | 59 | 100 | 42 | - | - | - | 59 | 38 | 81 |
| Bank of Kuwait and the Arab World | β | 87 | 56 | 65 | 54 | 52 | 41 | 58 | 55 | 58 | 39 | 76 |
| Allied Bank | δ | 66 | 41 | 48 | - | - | - | - | - | 52 | 40 | 82 |
| Société Nouvelle de la Banque de Syrie et Liban | β | 78 | 53 | 56 | 47 | 40 | 46 | 49 | 43 | 51 | 41 | 76 |
| Bank Saderat Iran | γ | 100 | 53 | 45 | 68 | 33 | 30 | 35 | 40 | 50 | 42 | 70 |
| Inaash bank | δ | 67 | 37 | 46 | - | - | - | - | - | 50 | 43 | 72 |
| Bank du Libanaise pour le Commerce/BLC Bank | β | - | 65 | 46 | - | 30 | 28 | 68 | 63 | 50 | 44 | 87 |
| Metropolitan/Standard Chartered Bank | γ | 58 | 35 | 34 | - | - | - | - | 70 | 49 | 45 | 70 |
| First National Bank | β | 55 | 37 | 28 | 34 | 48 | 65 | 58 | 68 | 49 | 46 | 71 |
| Banque Pharaon et Chiha | δ | 100 | 20 | 54 | 61 | 29 | 49 | 43 | 34 | 49 | 47 | 70 |
| Near East Commercial Bank | δ | 53 | 33 | 50 | 33 | 43 | 60 | 78 | 28 | 47 | 48 | 69 |
| Wedge Bank Middle East | δ | 60 | 43 | 42 | 39 | - | - | - | - | 46 | 49 | 68 |
| Jordan National Bank | δ | 58 | 42 | 47 | 37 | - | - | - | - | 46 | 50 | 68 |
| United Credit Bank | γ | 91 | 51 | 29 | 31 | 27 | - | - | - | 46 | 51 | 67 |
| Bank of Lebanon and Kuwait | γ | 62 | 43 | 38 | 33 | - | - | - | - | 44 | 52 | 66 |
| Jammal Trust Bank | γ | 87 | 32 | 28 | 36 | 28 | 31 | 83 | 27 | 44 | 53 | 71 |
| Banque de l'Industrie et du Travail | γ | 69 | 45 | 47 | 44 | 29 | 32 | 40 | 35 | 43 | 54 | 67 |
| Société Bancaire du Liban | α | 54 | 52 | 37 | 30 | 21 | - | - | - | 39 | 55 | 62 |
| Federal Bank of Lebanon | γ | 58 | 22 | 25 | 62 | 17 | 17 | 17 | 73 | 36 | 56 | 59 |
| Banque Lati | δ | 70 | 36 | 30 | 34 | 28 | 27 | 34 | 31 | 36 | 57 | 63 |
| Al Ahli International Bank | γ | - | - | - | 66 | 15 | 23 | 46 | 29 | 36 | 58 | 60 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crédit Bancaire/Creditbank | *β* | 60 | 26 | 30 | 32 | 26 | 34 | 40 | 39 | 36 | 59 | 65 |
| National Bank of Kuwait (Lebanon) | γ | 59 | 22 | 22 | 34 | 18 | 25 | 40 | 52 | 34 | 60 | 59 |

*Table 2. Global Technical Efficiency (TE) Scores from the CRS input-oriented DEA models.*

increased from 9 banks to 17 (28% of the total number of banks) including an increase in the number of efficient large-sized α banks from 1 to 6 banks (10% of the total banks). The results indicate that only 6 (42%) out the 14 large-sized banks are locally efficient and the remaining 48% are inefficient with scope for improvements. The DEA results give useful information for benchmarking and re-engineering the operation for such inefficient banks. For example, in year 2001, Citibank has a PTE inefficient score of 82% for which DEA gives a virtual-input combination of 12.1% of "Banque de l'Habitat", 12.5% "North Africa Commercial Bank", 0.7% of "Rafidain Bank" and 61% of "Saudi National Commercial Bank" for producing Citibank's activities. The combined efficient banks form the frontier surface for Citibank to improve its operations. Further analysis on averages of TE efficiencies are presented in Table 3 from which two observations can be made. The terrorist attack on USA in September 2001 affected LBS performance as it dropped about 9.3% from 82 to 75. Similarly, the political tension in 2004 that led to the assassination of the late Prime Minister H.E. Rafic Hariri had dropped the LBS performance by 10% as shown from the yearly italic bold averages in Table 3.

| **Year** | **97** | **98** | **99** | **00** | **01** | **02** | **03** | **04** |
|---|---|---|---|---|---|---|---|---|
| **No. of Banks** | 60 | 59 | 58 | 53 | 51 | 46 | 45 | 45 |
| **No. of Efficient Banks** | 14 | 11 | 16 | 13 | 15 | 18 | 13 | 8 |
| **Average TE** | 88 | 76 | 76 | ***82*** | ***75*** | 76 | ***84*** | ***80*** |
| **Average Inefficiency** | 13 | 31 | 31 | 22 | 33 | 31 | 19 | 25 |
| **Standard Deviation (Std)** | 10 | 18 | 17 | 17 | 20 | 20 | 17 | 17 |
| **Minimum Inefficiency** | 70 | 43 | 47 | 50 | 39 | 40 | 41 | 50 |
| **LB= Av. TE- std** | 78 | 58 | 59 | 65 | 55 | 56 | 67 | 63 |
| **UB= Av. TE+ std** | 98 | 94 | 93 | 98 | 96 | 96 | 100 | 97 |
| **% Banks in [LB, UB]** | 52 | 54 | 53 | 47 | 49 | 48 | 76 | 49 |

*Table 3. Average Technical Efficiency of Banks: 1997-2004*

| **Year** | | **97** | **98** | **99** | **00** | **01** | **02** | **03** | **04** | **Av.** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bank Name** | G | **TE** | **TE** | **TE** | **TE** | **TE** | **TE** | **TE** | **TE** | **TE** | **Action** |
| **Banque Audi** | α | 92 | 80 | 78 | 79 | 78 | 80 | 95 | 92 | 84 | Merged in 04 |
| **Banque Saradar** | α | 98 | 100 | 100 | 100 | 100 | 100 | 100 | - | 100 | Merged in 04 |
| **Banque de la Mediterrannée** | α | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 90 | 99 | Merged in 00 |
| **Allied Bank** | γ | 73 | 55 | 60 | - | - | - | - | - | 52 | Acquired in 00 |
| **Byblos Bank** | α | 100 | 85 | 83 | 84 | 80 | 72 | 91 | 89 | 85 | Merged in 01 |
| **Wedge Bank Middle East** | γ | 77 | 65 | 65 | 62 | - | - | - | - | 46 | Acquired in 01 |
| **ABN AMRO Bank** | *β* | 100 | 97 | 97 | 95 | 94 | - | - | - | 95 | Acquired in 02 |
| **Fransabank** | α | 97 | 83 | 93 | 92 | 88 | 78 | 91 | 81 | 88 | Merged in 02 |
| **United Bank of Saudi and Lebanon** | γ | 94 | 94 | 81 | - | - | - | - | - | 82 | Acquired in 00 |
| **Banque de la Békaa** | γ | 84 | 74 | 85 | 92 | 100 | 100 | - | - | 82 | Acquired in 02 |
| **Intercontinental Bank of Lebanon** | α | 90 | 56 | 53 | 70 | 74 | 76 | 100 | 100 | 67 | Merged in 1999 |
| **BCP Oriel Bank** | *δ* | - | 100 | - | - | - | - | - | - | 100 | Acquired in 1999 |
| **Crédit Bancaire/Creditbank** | *β* | 73 | 51 | 52 | 50 | 48 | 50 | 53 | 54 | 36 | Merged in 2002 |
| **Crédit Lyonnais Liban** | *δ* | 100 | 100 | 100 | 100 | 100 | - | - | - | 100 | Acquired in 2002 |
| **Société Générale de Banque au Liban** | *β* | 94 | 81 | 73 | 100 | 69 | 66 | 71 | 62 | 76 | Merged in 2000 |
| **Inaash bank** | γ | 81 | 61 | 64 | - | - | - | - | - | 50 | Acquired in 2000 |

*Table 4. Tracking relative technical efficiencies after mergers and acquisitions*

### 3.2 Technical Efficiencies Analysis and Mergers and Acquisitions

Table 4 Shows the yearly TE average values to study the effect of mergers and acquisitions over the 8-year period. It is observed that 70% of the most mergers and acquisitions involve at least one α efficient bank. The immediate TE value may drop up to 10% with increased TE average values until gaining full efficiency in most cases. However, the mergers and acquisitions among other banking groups even if they involve efficient banks, they are not managing to gain back their original TE efficiencies before merger with a declining pattern in TE average values, the reason may be that the increase in size of new merged units may be creating more complex operational problems that they do not have enough experience or able to handle well as compared to large-sized bank mergers.

### 3.3 Technical efficiencies related to bank failures

Figure 1 shows the yearly technical average efficiencies of the "closed or ended" banks during the 8-year period. A warning interval is determined by computing the LB (thick dashed lower horizontal line) and UB (thick upper horizontal line) values of all operating banks in a given year, as explained in Table 3. The monitoring body should examine all banks with TE values falling outside the warning interval with LB and UB limits derived from the yearly average of all banks +/- one standard deviation of the sector's average. Identified outliers in either direction should be called to explain their reasons for any sharp upward or downward trend. As it can be shown all failed banks have dropped outside the LB limits, each bank is having a downward trend. Except the case of Bank Al Madina which showed a sharp up and down movements, being the most inefficient bank to become among the 100% efficient banks in a period of two years. The DEA tool would spot such sharp movement for the BCC controlling unit to investigate the reasons behind such behaviour. In fact, Al-Madina bank is currently being investigated by the united nation commission with the assassination of the late Prime Minister due to its strong relationship with the chiefs of the military army of a neighbouring country which was acting as the main guardian of the Lebanese security during the 8-year period.

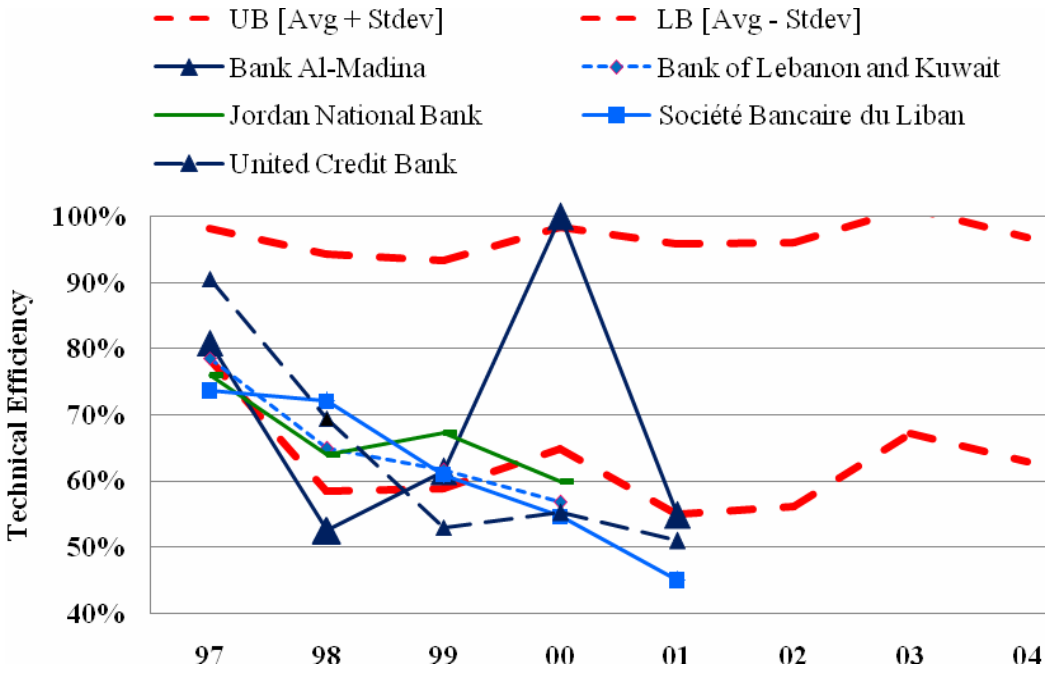


*Figure 1. Relative TE of failed banks outside the one-standard deviation interval*

## 4 CONCLUSION

In this paper, we have developed a data envelopment analysis approach to evaluate the performance of the Lebanese banking sector over an eight year period. It is the first study of its kind that investigates of the Lebanese banks sector by such new DEA approach. DEA has enabled the simultaneous consideration of multiple inputs and outputs to classify LBS in terms of relative efficient or inefficient banks. The approach has also been shown to be able to provide early warning signals for banks at risk, hence they can be invited immediate scrutiny and investigation by the banking control commission of the Lebanese central bank in charge of supervising and controlling the sector. DEA also can be used to certify banks based on their yearly relative DEA efficient scores and provide guidance to improve inefficient of inefficient banks. It is more robust that uses multiple measures to derive its efficiency score and would provide a better alternative than other CAMEL and regression approaches that use single-input to single-output ratios which are often selected individually by bank to make partial claim on performance. DEA approach can also be measured the impact of financial policies on the sector‘s performance over time. Further studies on DEA performance analysis is currently investigated by the authors using both window analysis and Malmquist index approaches. They provide two alternative approaches for tracking bank/sector performance, and monitoring impact of policies over different time periods, Camnho and Dyson (2006), Tortosa-Ausina *et al.* (2008).

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*Figure 1. The number of 100% pure technical efficiencies compared to the 100% scale efficiencies*