Quantifying Management's Role in Bank Survival Using Data Envelopment Analysis (DEA): Case of Jamaica

Lisa-Kaye Wallace[1]
Financial Stability Department
Research and Economic Programming Department
Bank of Jamaica

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Abstract

This paper presents a new approach for quantifying bank's management quality, using a data envelopment analysis (DEA) model that combines multiple inputs and outputs to compute a scalar measure of efficiency. This measure will seek to capture a fundamental and crucial element of a bank's success, which is its management efficiency. The results show that, on average, differences in management quality scores exist between institutions that failed during the 1996-1998 financial sector meltdown relative to banks that survived. Additionally, during this period, the technical efficiency scores for foreign-owned banks were higher in comparison to scores for indigenous banks. In examining the post-crisis period: 2002-2008, it was found that the three largest commercial banks, on average, exhibited lower management efficiency scores in contrast to smaller commercial banks.

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[1] The views expressed in this paper are those of the author and not necessarily those of the Bank of Jamaica.

1. Introduction

Internal mismanagement is generally acknowledged to be a key threat to the long-term survival of an institution, however, it is generally excluded from early warning models, for lack of an objective measure. Most failure prediction models include variables that can be categorized under four of the five CAMEL rating factors. The variable that is typically missing from prediction models is the one which assesses management quality.[2] Many consider this a curious paradox since the quality of management is often cited as the leading cause for bank failures. Pantalone and Platt (1987) argued that it is the management of the bank that determines success or failure. They further stated that, most often, banks fail because they have chosen paths that are excessively risky for the returns that they receive and because these paths make them particularly vulnerable to adverse economic conditions. Additionally, Seballos and Thompson (1990) noted that the ultimate determinant of whether or not a bank fails is the ability of its management to operate the institution efficiently as well as to evaluate and manage risk.

In light of the recent failure of a number of financial institutions globally, the need for more effective prediction models that incorporate management quality has become evident. However, Barr and Siems (1996) noted that an early warning system cannot replace the on-site examination, which allows for personal interaction with the bank's management and employees and permits first-hand evaluation of operating procedures, levels of risk taking and long-range strategic planning. In this context, an effective early warning system that incorporates management quality can complement the on-site examination process by identifying troubled institutions that need early examination or possible intervention, thereby, minimizing the risk of costly bailouts.

In the past few years, data envelopment analysis (DEA) has been frequently applied to banking industry studies. Most of the studies have found DEA to be a useful tool in examining management efficiency. Barr et al (1993) examined the technical efficiency of

[2] Bank examiners generally evaluate a bank's health using an overall rating system called CAMEL, based on Capital adequacy, Asset quality, Management quality, Earnings ability and Liquidity positions, but assessing management is more difficult and is considered a subjective matter.

930 US commercial banking institutions, over a five year period, using six inputs and three outputs.[3] The results from the input-oriented DEA model showed that significant differences in management quality scores existed between failed and non-failed banks. The scores for surviving institutions were consistently within a range of 0.814 to 0.837, the scores for failed banks ranged between 0.631 and 0.799. They further noted that these differences are detectable long before failure occurs and increase as the failure date approaches.

Similarly Pires Goncalves (2006) analysed managerial efficiency of the largest 50 Brazilian banks over a twelve year period using an input-oriented DEA model. The model utilizes four outputs and three inputs to approximate the decision making nature of bank management.[4] The results show differences in management quality scores between institutions. The finding suggest that the five largest Brazilian banks, among them two public banks, all revealed an efficiency score of 1.00 during each year of the sample period. The finding is partially surprising since strong criticism exist in Brazil against publicly-owned banks that are supposedly inefficient.

Jackson (2000) derived the relative technical efficiencies of the Turkish commercial banking system by implementing DEA on a cross-section of 48 banks in 1998. The input oriented methodology used two inputs and three outputs.[5] The findings suggest that on average, banks could produce output with approximately 33.0 per cent fewer inputs. He also found that both bank size and bank profitability have significant positive effects on efficiency.

Contrary to the above studies, Miller et al (1995) findings suggested that managerial inefficiency does not provide significant information to explain Connecticut bank

[3] The inputs used in this model were: full-time equivalent employees, salary expenses, fixed assets, non-interest expense, total interest expense and purchased funds. Correspondingly, the outputs included, deposits, earning assets and interest income.
[4] The inputs included number of employees, labour costs, number of branches and funding costs. The outputs on the other hand were deposits, savings, and interest income.
[5] The input variables used by Jackson (2000) include, number of employees, non-labour operating expense and direct expenditure on buildings and amortization expense whereas the outputs are loans, demand deposits and time deposit.

failures. By extension the result indicate that the average efficiencies for all banks do not indicate a clear pattern between survived and failed institutions. Additionally, the study was conducted using different combination of the number of inputs and outputs variables which demonstrate that the level of bank efficiency generally increases with the degree of disaggregation of outputs and inputs.

Currently, the use of a quantitative measure of management quality is, for the most part, absent from the Bank of Jamaica's formal analysis of the financial sector. This paper will seek to construct an efficiency measure for the Jamaican banking system to help determine and, by extension, distinguish management quality between banks that survived and those that failed during the period 1995 to 1998. The results from this crisis period will be used as a benchmark for assessing management quality during the post-crisis period (2002-2008). Quality will be assessed using a DEA model, which views a bank as transforming multiple inputs into multiple outputs. Since commercial banks control greater than 50.0 per cent of assets within the financial system, the focus of the analysis will be on commercial banks.

The paper is structured as follows: Section 2 provides a brief overview of the causes of the financial sector crisis in Jamaica during the mid 1990s. Section 3 highlights the data and methodology employed in this study. Section 4 presents the findings and section 5 presents the conclusion and policy implications of the findings.

2. Jamaica Banking Sector Distress: 1995-1998

During the mid 1990's, the Jamaican banking system underwent a financial meltdown. In 1989 there existed 11 commercial banks. However, by mid-1998, the size of the commercial banking sector was reduced to 9 banks and thereafter, 6 commercial banks (see **Table 1.0**).[6] The experience of the meltdown demonstrated that chronic weaknesses in the banking sector can have significant costs and highlighted the importance of sound management practices. Macroeconomic and microeconomic factors, coupled with

[6] After the crisis period three commercial banks were merged (Citizen Bank, Eagle Commercial Bank and Workers Banks) to form Union Bank and subsequently RBTT.

regulatory weaknesses, all contributed to the crisis.[7] However, for the purpose of this paper the main focus will be on microeconomic factors, specifically, poor management practices which incorporates bad lending decisions, poor risks assessment, corruption and over-investment in non-core business.[8]

Internal mismanagement by some institutions was cited as one of the dominant factors that contributed to the downturn in the Jamaican banking system. According to Panton (1998), poor loan administration, which included emphasis on collateral instead of potential income flows, and lending to related parties were among the major factors which led to the growth in the banks' bad debt portfolio. In the case of collaterals, many real estate based collaterals were overvalued, signalling that loans could not be liquidated in the event that they went bad. This was compounded by the dilution of skills, which accompanied a too-rapid expansion of the industry and which saw inexperienced loan officers failing to conduct appropriate risk assessments. Panton (1998) also alluded to the fact that occasionally, larger clients were not pressured to service loan obligations on a regular basis, pointing to inherent deficiencies in the credit management policies and procedures in some commercial banks.

Further evidence of weak management was manifested in the high operating costs within some institutions. Over the period 1991 to 1994, the ratio of banks' overhead expenses to core net revenue declined from 102.5 per cent to 69.2 per cent. This ratio subsequently increased to 143.9 per cent by the end of 1997, reflecting greater remuneration to employees and increases in expenditure for rent and fixed assets, which were higher than the average quarterly growth rate of net interest income (Foga et al, 1997). Additionally, inadequate provision for loan losses made by banks despite a burgeoning non-performing loan portfolio was a further cause for concern. Over the period March 1993 to December 1997, although the banks' portfolio of doubtful debt grew by a quarterly average rate of

[7] See Green (1999), Foga el al (1997) and Panton (1998) for further details with respect to the macroeconomic and regulatory weaknesses that contributed to the crisis.
[8] Foga et al (1997) highlighted the fact that there is the view that the problems that emerged in the Jamaican financial sector over the middle part of the 1990's, have been more related to factors such as poor risk assessment and unsound management techniques on the part of financial institution.

18.5 per cent, there was no commensurate increase in provisioning. In fact, during that period, provisions for loan losses grew by a mere 9.8 per cent. As a consequence, the ratio of loan loss provisions to non- performing loans declined precipitously from 63.0 per cent in March 1993 to 38.3 per cent in 1998.

Bonnick (1998) identified "the quality of indigenous management of the troubled institutions as a contributing factor that led to the crisis." The fact that foreign-owned and controlled institutions survived the financial collapse while indigenous banks failed can partly be explained by the prudential guidance of overseas head offices. Further, the strong relationship between poor management and its existence at indigenous banks could be a consequence of the lack of proper internal control processes coupled with their inability or unwillingness to resist political and other pressures (see also, McIntosh, 1999).[9]

By extension, Langrin (2005) noted that the non-failure of foreign banks during the Jamaican financial meltdown could be due to the fact that over the years, these institutions had developed and maintained a reputation of being more profitable and efficient relative to their domestic counterparts. Additionally, foreign banks were less vulnerable to a bank run or liquidity problems given that they were subsidiaries of huge banking institutions abroad with massive resources and access to leading edge technology and training in comparison to domestic banks.

Notably, in examining two basic efficiency ratios over the period 1989-1998, it was found that foreign-owned banks (BNS, CBNA and CIBC) were managed more efficiently. Return on assets, which is an indicator as to how well institutions are utilizing its assets to generate profit, was significantly higher for foreign-owned banks relative to indigenous institutions. Foreign- owned institutions had an average ratio in excess of 1.0

[9] Local banks tend to be more nationalistic and tend to have 'helping Jamaica' as part of their mission statement. While this is good for the country, it might have interfered with management decisions that should be based solely on profitability of the bank. Foreign banks, on the other hand, operated according to international standards set by their head offices and could be less persuaded/ advised by government on banking matters.

per cent in contrast to a negative return on assets for local owned institutions, which averaged negative 0.82 per cent over the period (see **Figure 1.0**). In addition, the expense to total revenue ratio which seeks to determine how well management is controlling expense relative to income also showed a marked deviation between locally and foreign-owned banks. On average between 1989 and 1998, foreign-owned institutions managed to control their expenses at approximately 74.0 per cent of income while locally-owned institutions expense to revenue ratio exceeded 100.0 per cent (see **Figure 2.0**). Langrin (2001) posited that it is expected that higher profit indicators will be positively related to the survival time and negatively related to the likelihood of failure. The opposite is expected to be true for higher cost ratios.

Figure 1.0

Average Return on Assets for Commercial Banks: 1989-1998

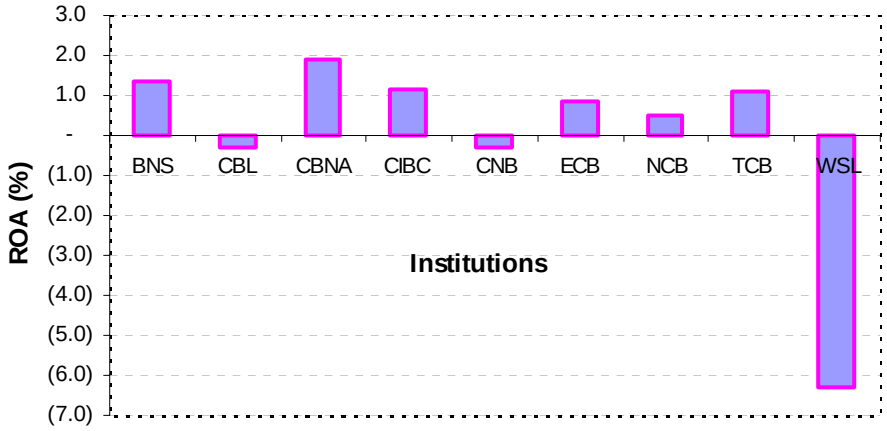
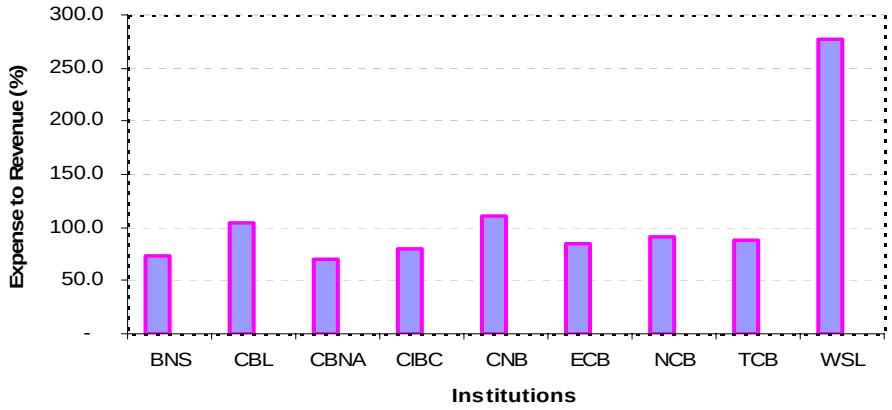


Figure 2.0

Average Total Expense to Total Revenue for Commercial Banks: 1989-1998



3. Methodology & Data

3.1 Data Envelopment Analysis (DEA)

DEA has fast become a popular method in assessing financial institutions efficiency. Single ratios, such as total operating income divided by total operating expense, suffer from several limitations. For example, while such ratios may provide an overall measure of operational efficiency, they fail to indicate the resource allocation and product decisions made by management because the numerator and denominator are aggregate measures. Sexton (1986) highlighted the fact that when several non-aggregated single input-output ratios are used to assess the myriad of decisions made by management, the ratios collectively present a morass of numbers that give no clear evidence of the efficiency of a bank. One ratio may show that the bank is highly efficient while another displays a highly inefficient operation. Consequently, such ambiguity makes ratio analysis ineffective in measuring true efficiency.

In light of the limitations of single ratio analysis, Charnes, Cooper and Rhodes (1978) engineered a non-parametric frontier estimation methodology known as DEA. Data envelopment analysis is a linear programming technique that converts multiple inputs and

output into a scalar measure of efficiency.[10] Essentially, the DEA technique maximizes the ratio of total weighted output to total weighted inputs for a decision making unit (DMU). In general, the model places higher weights on those inputs the firm uses least and those outputs the firm produces most. This conversion is accomplished by comparing the mix and volume of services provided and the resources used by each bank compared with all other banks.[11] Each bank is evaluated against a hypothetical bank with an identical output mix that is constructed as a combination of efficient banks. DEA identifies the most efficient banks in a population and provides a measure of inefficiency for all others. The most efficient banks are rated a score of one, while the less efficient institutions score between zero and one. DEA does not give a measure of optimal efficiency. It will only differentiate the least efficient banks from the set of all banks (even where all banks might be inefficient). Thus, the efficient institutions calculated using DEA establish the best practice frontier.[12]

Unlike other methodology, the DEA methodology is directed to frontiers rather than central tendencies. Because of this unique orientation, DEA has proven particularly adept at uncovering relationships that remain hidden for other methodologies, (Barr and Siems (1996)). Furthermore, they stated that the assumptions required by parametric approaches regarding the distribution of the error terms are very restrictive. DEA is an alternative approach that assumes that all deviations from the frontier are inefficiencies without any prior assumptions.

3.2 **Limitations of Data Envelopment Analysis**

DEA has several limitations. One of the main shortcomings is its assumption that the entire deviation from the frontier is considered as inefficiency. Hence, measurement errors and other stochastic effects will be incorporated into the DEA measure as

[10] Technical efficiency measures the maximum possible output that a given amount of inputs can produce.
[11] Essentially, Barr (1993) identified a number of variables as surrogates for managerial performance of banks and argued that "these variables, while not directly measuring managerial ability, do nevertheless capture, the ex-post consequences of management's decisions
[12] Over time, production technology can change causing shifts in the best practice technical frontier. These shifts could be due to more experience as time passes, increased knowledge, innovations in management or in production processes, financial liberalisation or deregulation and increased competition

inefficiency. In other words the DEA methodology assumes data are free from measurement errors. An additional limitation is the fact that the selection of variables for the model is of critical importance, and the resulting efficiency measure is highly sensitive to the variables selected. Furthermore, efficiency scores are computed relative to all other banks under evaluation, therefore changes in the number of banks in the population and changes in the set of input and output variables in the model can cause the efficient frontier to change. Similarly, if new banks are added or become part of the frontier, existing banks may have their efficiency scores altered.

3.21 Benefits of Data Envelopment Analysis

One of the strengths of DEA is that it is less data demanding compared to other methodologies. Furthermore, DEA does not require preconceived structure or specific functional form to be imposed on the data in identifying and determining the efficient frontier, errors and inefficiency structures of decisions making units. Avkiran (1999) acknowledges the comparative benefit of the DEA as being that it allows the researcher to choose any kind of input and output of managerial interest, regardless of different measurement units. Another useful feature of DEA is that each decision making unit (DMU) is assigned a single efficiency score, hence allowing for ranking amongst the DMU in the sample. For example, since a DMU is compared to a set of efficient DMUs with similar input-output configuration, the DMU in question is able to identify whether it has used input excessively or its output has been under produced.

More importantly, Pires (2006) noted that the focus of DEA is on the individual observations in contrast to the focus on averages and estimation of parameters associated with regression approaches. Pires (2006) posited that because of this unique orientation, DEA is particularly adept at uncovering relationships that remain hidden from other methodologies as DEA produces relative efficiency measures.

3.3 **Evaluation Technique**

The model adopted is similar to that employed by Barr, Seiford and Siems (1993), also known as the CCR input-oriented model.[13] The model assumes that there are *n* DMUs to be evaluated and each DMU consumes varying amounts of *m* different inputs to produce *s* different outputs. Specifically, DMUj consumes amounts Xj = {xij} of inputs (*i = 1*,..., *m*) and produces amounts Y_j = {y_{rj},} of outputs (*r = 1*,..., *s*). The model also assumes that the observed values are positive, i.e., $x_{ij} > 0$ and $y_{ij} > 0$. The *s x n* matrix of output measures is denoted by *Y* and the *m x n* matrix of input measures is denoted by *X*.

Essentially, the CCR model seeks to establish which of *n* DMUs determine an efficient frontier. To be efficient, DMU_j must lie on this frontier, otherwise they are termed inefficient. Identification of the efficient frontier is accomplished by the following mathematical programming problems:

Envelopment form (CCR_p)

$$\min_{\theta,\lambda,s^+,s^-} z_0 = \theta - \in \cdot 1 s^+ - \in \cdot 1 s^-$$

$$\text{subject to} \qquad Y\lambda - s^+ = Y_0,$$

$$\theta X_0 - X\lambda - s^- = 0,$$

$$\lambda, s^+, s^- \geq 0;$$

Multiplier form (CCR_D)

$$\max_{\mu,\upsilon} w_0 = \mu^T Y_0$$

$$\text{subject to} \qquad v^T X_0 = 1$$

$$\mu^T Y - v^T X \leq 0,$$

$$-\mu^T \leq - \in \cdot 1,$$

$$-v^T \leq - \in \cdot 1.$$

[13] The CCR model is based on the work of Charnes, Cooper and Rhoades (1978).

The primal problem is referred to as the envelopment form while the dual problem is referred to as the multiplier form. The duality theorem of linear programming guarantees that $z^*_0 = w^*_0$ so that only one problem needs to be solved. The particular DMU_0 being analyzed is efficient if and only if $z^*_0 = w^*_0 = 1$. Failure to achieve efficiency occurs when $\theta^* < 1$ or any component of s^{+*} or s^{-*} is not zero. These values identify the sources and amounts of inefficiency in the corresponding outputs and inputs. This process is repeated *n* times, once for each DMU_j which is to be rated. That is, we solve CCRp with $\{X_0, Y_0) = (X_j, Y_j)$ for j = 1,..., n. The objective function values partition the set of DMUs into two subsets; DMUs for which $z^*_0 = 1$ are efficient and determine the efficient frontier, while DMUs for which $z^*_0 < 1$ are inefficient and lie beneath this surface.

The (scalar) variable θ in the primal problem is the (proportional) reduction applied to all inputs of DMU_0, the DMU being evaluated, to improve efficiency by movement toward the frontier. The non-Archimedean (infinitesimal) constant, ε, appears both in the primal objective function and as a lower bound for the multipliers in the dual problem (to guarantee positivity). The presence of the (non-Archimedean) ε in the primal objective function effectively allows the minimization over θ to preempt the optimization involving the slacks. Thus, optimization is essentially a two-stage process with maximal reduction of inputs being achieved first via the optimal θ^* and then in the second stage movement to the frontier achieved via the slack variables (s^+, s^-). Evidently, the following two statements are equivalent:

(i) A DMU is efficient if and only if the following two conditions are satisfied:

(a) $\theta^* = 1$;

(b) All slacks are zero.

(ii) A DMU is efficient if and only if $z^*_0 = w^*_0 = 1$.

In either case, the non-zero slacks and the value of $\theta^* \leq 1$ identify the sources and amount of any inefficiencies that may be present.

3.4 Data Selection and Description

The variables selected for the purpose of this paper focus on bank management's basic allocation, control and product mix decisions. [14] Hence, the model includes variables that are most descriptive of management decision making role in a bank's intermediation process. Because of the multitude of functions performed and decisions made by management, a descriptive model of bank management quality must contain several inputs and outputs. The model utilizes semi-annual balance sheet and income statement data obtained from the Bank of Jamaica over the period June 1989 to December 1998 and June 2002 to December 2008 for commercial banks. The performance measure describes five input and five output variables (see **Table 2.0**).

Table 2.0 - Input and output variables utilized in this model

Inputs	Outputs
Salary expenses	Deposits
Value of Fixed assets	Other Earnings assets
Non-interest expense	Interest income
Interest expense	Non-Interest Income
Purchased funds	Loans

In essence, the input-output variables were selected based on the premise that the most efficient banks allocate resources and control internal processes by effectively managing salary expenses, facilities, non-interest expense, interest expense and purchased funds while working to maximize deposits, loans, other earning assets and interest income.[15] Moreover, given that, the operations of all bank activities involve labour, materials, machines, and buildings, management certainly has a great deal of discretion concerning the allocation of these resources. For instance, management determines the number of

[14] Barr, Seiford and Siems (1993) presented an approach to measuring a bank's managerial quality using publicly available financial information. Meyer and Pifer (1970) advocated that over a period of time differences between efficient management and poor management will be systematically reflected by balance sheet and income data, they further posited that, an analysis of such data should enable prediction failure.

[15] Purchased funds include funds that are needed in addition to all other deposits to adequately service the bank's investments and provide needed liquidity. This includes funds due to Bank of Jamaica, commercial banks, specialized institutions and other financial institutions. Additionally, securities sold under repurchase agreement are included. Earning assets on the other hand incorporate all interest bearing assets such as loans, investments, funds due from Bank of Jamaica and other deposit taking institutions.

employees needed to perform a desired function at a desired level of service. They also establish salary levels and they determine the types of facilities to build, where to build and how to furnish and operate them (see Table 3 and Table 4).[16]

Furthermore, management also decides what other non-interest expenses to incur, such as legal assistance and administrative expenditures related to maintaining and liquidating foreclosed real estate and other assets. The five inputs and five outputs essentially reflect the key activities of management. Another input associated with acquiring deposits in stage one is total interest expense. Management establishes the types of deposits and the interest rate levels offered to depositors. While interest rates are largely influenced by market forces and monetary policy, management makes decisions regarding the composition of deposits which directly influences total interest expenditures.

In terms of loans, there was a sharp average decline of 5.9 per cent in loans by failed banks during the financial crises period relative to average growth of 17.0 per cent during the pre-crisis period.[17] Non-failed institutions experienced positive growth in their loan portfolio during the crisis period albeit lower than in the pre-crisis period. The negative growth experienced by failed institutions during the crisis period may have reflected an inability to lend given liquidity problems.

Average growth in non-interest income and interest income declined for both failed and non-failed banks during the crisis period relative to the pre-crises period. However, during the crisis period, the pace of decline in the growth of interest income was slower for failed banks, possible due to higher earnings assets as the number of institutions that failed were greater than the number of banks that survived. Additionally, failed institutions could have been charging higher interest rates to low quality borrowers

[16] Table 3.0 and Table 4.0 provides a list of the inputs and outputs used in this study and also gives the average growth rates of these variables for failed and non-failed banks for the sample periods 1989-1995 (pre-crisis) and 1996-1998 (crisis), respectively. The first six columns of each table present the average input and output growth rates of banks that survived and the latter six columns present the rates for the institutions that failed.

[17] Failed banks refer to those institutions that were declared insolvent by the regulatory authority at some point between 1996 and 1998.

indicative of the fact that these institutions' loan requirements were less stringent relative to surviving banks.

Deposits on average grew by 19.2 per cent for failed institutions during the pre-crisis period relative to 18.8 per cent for banks that survived, indicative of the fact that failed institutions might have been offering a higher rate of interest so as to attract higher levels of deposits. However, the average rate of growth of deposits for failed banks decelerated to 6.1 per cent relative to 8.8 per cent for non-failed institutions during the crisis period (1996-1998). The growth that occurred for failed institutions was primarily influenced by the operations of NCB that experienced significant growth (47.0 per cent) in deposits during the latter half of 1996.[18] According to Langrin (2005), in the case of a banking crisis, healthy banks may be positively impacted in that informed depositors transfer their deposits from increasingly fragile banks to more healthy banks and thus may be used to explain the higher growth in deposits for surviving institutions.

The average growth of interest expense and non-interest expense input variables for failed institutions during and before the crisis period were higher relative to banks that survived. With respect to interest expense, the increase for failed banks was due to the fact that these institutions offered a much higher interest rate to depositors than the non-failed banks. The implication here is that failed banks were forced to offer a risk premium to depositors who threatened to transfer deposits to healthier banks. The growth in non-interest expense experienced by failed institutions during the crisis period was as a result of increased provisioning for loans and security losses, specifically for Workers Saving and Loans Bank (WSLB).

Prior to the crisis period, purchased funds were higher for failed institutions relative to non-failed institutions, indicative of the increased liquidity needs of failed institutions prior to the crisis. In contrast, the overall mean average growth of purchased funds during the crisis period was less for failed banks relative to banks that survived. The deceleration

[18] Notably, during the latter half of 1996, both domestic and foreign currency deposits increased sharply for NCB, possibly due to depositors moving funds from troubled institutions to banks that they had deemed profitably and efficient at the time (NCB failed in 1997).

in growth rate of purchased funds for failed banks was largely due to the closure of Century National Bank (CNB) in the first half of 1996 which had the second highest level of purchased funds among failing institutions. Furthermore, Eagle Commercial Bank (ECB) growth in purchased funds during the crisis period exceeded 100.0 per cent due to increased borrowings from the Bank of Jamaica.

During the crisis period, fixed assets on average grew at a faster rate for failed banks in comparison to non-failed commercial banks, principally due to NCB and WSLB.

4. Empirical Findings

Based on observed trends, institutions that failed during the 1996-1998 financial sector crisis generally experienced deterioration in their efficiency scores relative to banks that survived (see **Appendix A**, **Figure 3.0** and **Table 5.0**). The results showed that overall technical efficiency scores for failed institution were less than the scores for non-failed institutions. In particular, the mean efficiency scores for WSLB, CBL, ECB and NCB (failed banks) were 0.857, 0.974, 0.974 and 0.991, respectively. For the same period, the efficiency scores for CBNA, TCB, BNS and CIBC (non-failed banks) were 1.000, 1.000, 0.992 and 0.977, correspondingly.[19] Of importance is that the efficiency scores for CNB prior to its closure in 1996 indicated that the institution formed one of the benchmark banks. On the other hand, CIBC which was foreign owned and had survived the crisis had an efficiency score that was moderately less than that of NCB during the sample period. The literature suggest that the closer a bank is to its failure date the lower its DEA score, indicative of the fact that CIBC and CNB deviated from *a priori* expectations. Nevertheless, one possibly implication of these results is that bank efficiency scores may not provide full information to distinguish between survived and failed banks.

Despite the above deviations the model is nonetheless intuitively appealing, as it gave evidence of technical inefficiencies for most of the banks that failed for the period

[19] The mean efficiency scores for the institutions that failed (CNB, ECB, WSL, NCB and CBL) during the mid 1990's crisis, in some instances exceeded the efficiency scores of institutions (BNS, CBNA, CIBC and TCB) that survived the crisis.

leading up to the crisis period. In particular, the technical efficiency scores which capture management efficiency for WSL, ECB and CBL were significantly below 1.0 just before the on-set of the 1996-1998 financial sector meltdown.

The DEA results for the post-crisis period (2002-2008) showed that of the six commercial banks in operation, three institutions (CBNA, FCIB and FGB) had efficiency scores of 1.00 (see Appendix, **Table 6.0**). Notably, larger banks appear to be more technically inefficient (BNS, NCB and RBTT) than the smaller commercial banks. Of note, the mean efficiency score for failed institutions during the 1996-1998 crisis period was 0.959 relative to 0.992 for surviving institutions. In contrast, the average mean scores for commercial banks that were technically inefficient during the period 2002-2008 were 0.979 (BNS), 0.978 (NCB) and 0.988 (RBTT). These scores were higher than the scores obtained by failed institutions during the crisis but were lower relative to survived institutions. The less than efficient scores for the three largest banks could be due to increased risk taking given their relative size as well as the notion that large banks may be too big to fail (TBTF). Furthermore, Langrin (2001) noted that large banks may be less likely to fail, given the expected relative advantages of large banks such as, raising new capital, alleviating illiquidity and diversification of risks. In addition, during the post-crisis period, episodes of lower efficiency scores coincided with periods when there was macroeconomic volatility, for instance early 2003 and late 2008, indicative of reduced efficiency in these periods of uncertainty (see **Appendix**, **Figure 4.0**).

5. Conclusion and Policy Implications

In light of the current global economic climate and the number of financial institutions that have failed internationally, a number of steps have been taken to strengthen the banking system and regulatory framework of many countries. The quality of management has been cited as being crucial to the long-tem survival of an institution. However, due to the lack of an objective measure, assessing management quality was previously difficult and was considered a subjective matter. Therefore, the multiple input-output DEA model utilized in this paper is very relevant in this context, given its capacity to quantify management quality of financial institutions. One of the primary benefits of DEA is that

it allows for ranking amongst banks in the sample. A DEA score of 1.0 implies full technical efficiency, while a score less than 1.0 implies that a linear combination of other units from the sample could produce the same vector of outputs using smaller vector of inputs.

The results showed that, in general, banks that failed during the crises period had lower efficiency scores relative to institutions that survived. Nonetheless, the DEA scores for two institutions in particular deviated from *a priori* expectations and might be indicative of the fact that bank efficiency scores may not provide full information to distinguish between survived and failed banks. In other words, the results might also point to the fact that other factors aside from management quality such as political, economic and financial issues are contributing factors. Results for the post-crisis period indicated that the three largest commercial banks had efficiency scores less than 1.0. However, relative to the institutions that failed during the 1996-1998 financial sector meltdown, their average efficiency scores were higher.

This paper seeks to enhance the off-site surveillance of the Bank of Jamaica's early warning system framework.[20] The results from the input-oriented DEA model proxy the management factor in the CAMEL rating for banks in Jamaica. The utilization of bank management quality as measured by DEA scores is useful in identifying potential risks exposures in banks before they materialize and by extension could be used to complement the BOJ's on-site surveillance. In this sense, a bank's DEA efficiency scores from this model could be used by the Bank of Jamaica as an off-site surveillance tool to complement on-site examinations. Additionally, technical efficiency scores can help the Bank to identify inefficient banks and formulate strategies to improve efficiency.

[20] Off-site bank supervision entails mostly continuous monitoring of profitability, liquidity risk and capital adequacy. This process also involves the use of financial data to schedule and plan on-site examinations.

6. References

Avkiran, N.K. (1999), "An Application Reference for Data Envelopment Analysis in Branch Banking: Helping the Novice Researcher, *International Journal of Bank Marketing* 17 (5), 206-220.

Barr, R.S and Siems, T. F. (1996), "Bank Failure Prediction using DEA to Measure Management Quality", Working Paper, Federal Reserve Bank of Dallas (Dallas, TX).

Barr, R.S., Seiford, L.M., and Siems, T.F. (1993), "An Envelopment –Analysis Approach to Measuring the Management Quality of Banks", *Annals of Operations Research*, 38, pp.1-13.

Bonnick, Gladstone. (1998), "Storm in a Teacup or Crisis in Jamaica's Financial Sector", Paper Presented at the Annual Monetary Studies Conference, October 26-30, (Paradise Island, The Bahamas).

Coelli, T.J. (1996), "A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program", Centre for Efficiency and Productivity Analysis, University of New England, Armidale.

Foga. C. Stennett R., and Green P. (1997), "Stabilization and the Jamaican Commercial Banking Sector (1991-1997)" Research Department, Bank of Jamaica.

Forsund, Finn R., and Nikias Sarafoglou. 2002. "On the Origins of Data Envelopment Analysis." *Journal of Productivity Analysis* 17, no. 1-2: 23-40. EconLit with Full Text, EBSCOhost (accessed February 5, 2009).

Garcia, Lindgren. (1996), "Bank Soundness & Macroeconomic Policy", IMF Publication.

Green, P. (1999), "Preserving the Integrity of the Jamaican Financial System: The Challenges", BOJ working paper.

Humprey, D.B. (1991), "Flow Versus Stock Indicators of Banking Output: Effects on Productivity and Scale Economy Measurement", Paper Presented at the Western Economic Association Meetings in Seattle, Washington, June 29-July 3.

Jackson, Peter. (2000), "Evaluating the Technical Efficiency of Turkish Commercial banks: An Application of DEA and Tobit Analysis", Working Paper, University of Leicester.

Langrin, Brian R. (2005), "The Role of Foreign Banks in the Recent Jamaican Financial Crisis", *Social and Economic Studies* 54:1, 1-42.

Langrin, Brian R. (2001), "Do Financial Conglomerate Cause Banking Crises?" Working Paper, Research Services Department, Bank of Jamaica.

Lyroudi, K. and Angelidis, D. (2006), "Efficiency in the Italian Banking Industry: Data Envelopment Analysis and Neural Networks", *International Research Journal of Finance and Economics*, Issue 5.

McIntosh, Mariame. (1999), "Causes of the Financial Crisis", Working Paper, Bank of Jamaica.

Meyer, P.A. and. Pifer H.W. (1970). "Prediction of Bank Failures", Journal of Finance, 25, 853-868.

Miller, S.M. and Noulas A. (1995). "Explaining Recent Connecticut Bank Failures" Working Paper Series, Department of Economics, University of Connecticut.

Pantalone, C. C. and Platt, M.B. (1987), "Predicting Commercial Bank Failure Since Deregulation", *Economic Review*, July/August, 37-47.

Panton, N. (1998), "The Commercial Banking Industry in Jamaica: Some Issues of Efficiency 1990 – 1995", *Money Affairs*, Vol. XI, No., 1, January – June.

Pires Goncalves, Ricardo. (2006), "Management Quality Measurement: Using Data Envelopment Analysis (DEA) Estimation Approach For banks in Brazil," MPRA paper No. 11143, posted October 2008, Universitat Autònoma de Barcelona – UAB.

Sexton, T.R (1986), "The Methodology of Data Envelopment Analysis in Measuring Efficiency", An Assessment of Data Envelopment Analysis, ed. R. H Silkman (San Francisco: Jossey- Bass).

Siems, T.F. (1992), "Quantifying Management's Role in Bank Survival", *Economic Review*. First Quarter, 29-41.

Appendix A

Table 1.0

Details of Non-Failed and Failed Bank in Operation Before the Banking Crisis

Name of Bank	Abbreviated Name	Year Established	Total Assets end-Dec.1995	Year Intervened
Non-Failed Institution				
Bank of Nova Scotia	BNS	1829	J$33.1 billion	-
Canadian Imperial Bank of Commerce	CIBC	1920	J$7.1 billion	-
Citibank	CBNA	1960	J$2.9 billion	-
Trafalgar Commercial Bank	TCB	1985	J$0.6 billion	-
Failed Institutions				
Century National Bank	CNB	1984	J$5.4 billion	1996
Citizens Bank	CBL	1967	J$6.5 billion	1997
National Commercial Bank	NCB	1977	J$36.6 billion	1997
Workers Savings & Loan Bank	WSL	1979	J$6.6 billion	1998
Eagle Commercail Bank	ECB	1988	J$2.4 billion	1997

Table 3.0

Average Growth Rates of Bank-Specific Input-Output Variables During the Pre-Crises Period : 1989-1995

Variables	Survived					Failed					
	BNS	CBNA	CIBC	TCB	Overall Mean	CBL	CNB	ECB	NCB	WSL	Overall Mean
Outputs:											
Loans	16.8	21.3	19.8	26.8	17.2	17.3	19.8	22.0	16.2	21.0	17.0
Non-Interest Income	26.6	62.3	40.3	46.9	29.0	41.6	95.6	86.0	31.8	12.3	35.6
Other Earning Assets	22.6	23.2	17.5	41.0	20.5	23.5	24.7	29.2	24.3	21.2	22.2
Interest Income	22.0	22.4	22.7	38.2	21.8	27.4	24.7	29.4	22.8	28.1	23.0
Deposits	18.7	23.8	18.8	40.3	18.8	22.0	18.8	22.7	19.3	20.0	19.2
Inputs:											
Fixed assets	24.7	50.8	18.3	264.5	22.9	25.0	23.6	27.8	24.3	25.9	21.5
Salary Expense	21.5	22.6	25.2	52.4	20.6	31.5	36.1	39.3	26.7	23.8	24.0
Non-Interest Expense	22.5	23.1	23.0	48.0	22.0	26.0	26.0	39.5	21.7	31.2	23.0
Interest Expense	21.1	27.5	24.4	49.3	21.0	31.2	29.6	26.7	26.7	27.5	25.6
Purchased Funds	30.5	113.1	56.7	158.7	25.6	29.4	75.1	63.2	35.3	135.5	32.5

Note:
1. The pre-crisis period covers the period 1989 to 1995

Table 4.0

Average Growth Rates of Bank-Specific Input-Output Variables During the Financial Crises Period: 1996-1998

Variables	Survived					Failed					
	BNS	CBNA	CIBC	TCB	Overall Mean	CBL	CNB	ECB	NCB	WSL	Overall Mean
Outputs:											
Loans	6.5	49.8	0.5	13.1	6.1	-2.3	-	19.0	-2.3	-1.9	-5.9
Non-Interest Income	6.5	49.8	0.5	13.1	22.1	106.5	-	-72.7	37.4	82.3	16.1
Other Earning Assets	12.4	4.9	8.3	0.9	10.8	18.5	-	41.2	23.4	-2.2	19.5
Interest Income	6.5	12.0	-1.5	3.3	5.1	23.6	-	20.8	12.2	-8.5	7.9
Deposits	9.0	20.9	6.5	4.9	8.8	2.7	-	-2.1	10.4	-6.2	6.1
Inputs:											
Fixed assets	6.7	36.1	11.3	-3.0	7.5	3.7	-	-10.1	11.2	35.3	11.5
Salary Expense	15.5	12.9	11.8	27.0	14.6	18.8	-	-2.5	11.5	4.0	9.3
Non-Interest Expense	14.1	17.3	6.9	11.8	12.6	21.8	-	17.0	10.0	379.9	34.5
Interest Expense	6.4	10.9	1.0	-3.3	5.1	19.1	-	55.1	13.3	13.7	7.0
Purchased Funds	45.3	40.8	93.1	23.8	37.0	40.3	-	673.3	-1.3	61.3	13.0

Note:

1. The financial crisis covers the period 1996 to 1998

Table 5.0

EFFICIENCY SCORES: 1989-1995 (Pre-Crisis Period)

	BNS	CBL	CBNA	CIBC	CNB	ECB	NCB	TCB	WSL	Mean
Jun-89	1.000	1.000	1.000	0.984	1.000	1.000	1.000	1.000	0.887	0.986
Dec-89	1.000	1.000	1.000	0.968	1.000	1.000	1.000	1.000	1.000	0.996
Jun-90	1.000	1.000	1.000	0.946	1.000	1.000	1.000	1.000	0.967	0.990
Dec-90	1.000	1.000	1.000	0.957	1.000	1.000	0.991	1.000	1.000	0.994
Jun-91	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Dec-91	1.000	1.000	1.000	1.000	1.000	1.000	0.960	1.000	0.786	0.972
Jun-92	1.000	1.000	1.000	1.000	1.000	0.994	1.000	1.000	1.000	0.999
Dec-92	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.677	0.964
Jun-93	1.000	0.910	1.000	0.926	1.000	0.856	1.000	1.000	0.972	0.963
Dec-93	1.000	0.994	1.000	0.953	1.000	1.000	1.000	1.000	0.768	0.968
Jun-94	1.000	1.000	1.000	0.978	1.000	1.000	0.996	1.000	0.819	0.977
Dec-94	0.893	1.000	1.000	1.000	1.000	0.951	0.932	1.000	0.705	0.942
Jun-95	1.000	1.000	1.000	0.997	1.000	0.987	0.990	1.000	0.693	0.963
Dec-95	1.000	0.727	1.000	0.975	1.000	0.854	1.000	1.000	0.730	0.921
Mean	0.992	0.974	1.000	0.977	1.000	0.974	0.991	1.000	0.857	0.974

Table 6.0

DEA EFFICIENCY SCORES: 2002-2008 (Post Crisis Period)

	BNS	CBNA	FCIB	NCB	FGB	RBTT	Mean
Jun-02	1.000	1.000	1.000	1.000	1.000	0.919	0.986
Dec-02	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Jun-03	1.000	1.000	1.000	0.921	1.000	0.951	0.979
Dec-03	1.000	1.000	1.000	0.935	1.000	1.000	0.989
Jun-04	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Dec-04	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Jun-05	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Dec-05	1.000	1.000	1.000	0.979	1.000	1.000	0.996
Jun-06	1.000	1.000	1.000	1.000	1.000	0.979	0.996
Dec-06	0.989	1.000	1.000	1.000	1.000	1.000	0.998
Jun-07	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Dec-07	0.937	1.000	1.000	1.000	1.000	0.986	0.987
Jun-08	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Dec-08	0.774	1.000	1.000	0.850	1.000	1.000	0.937
Mean	0.979	1.000	1.000	0.978	1.000	0.988	0.991

Assumptions: Constant return to scale
5 outputs -non- interest income, loans,other earnings assets, interest income & deposits
5 Inputs- Fixed assets, Salary expense, non-interest expense, interest expense & purchased funds

Figure 3.0

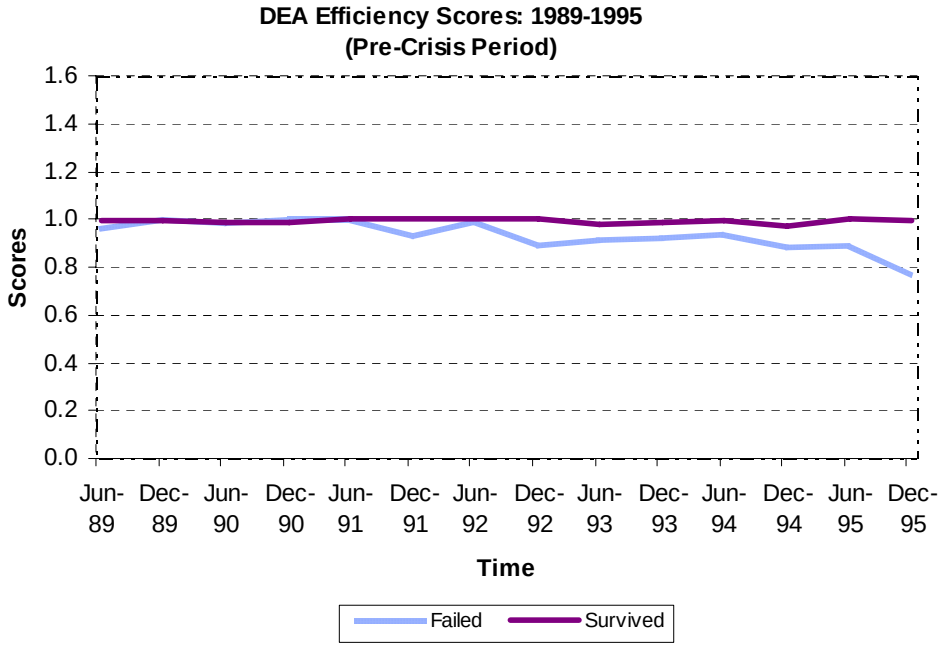
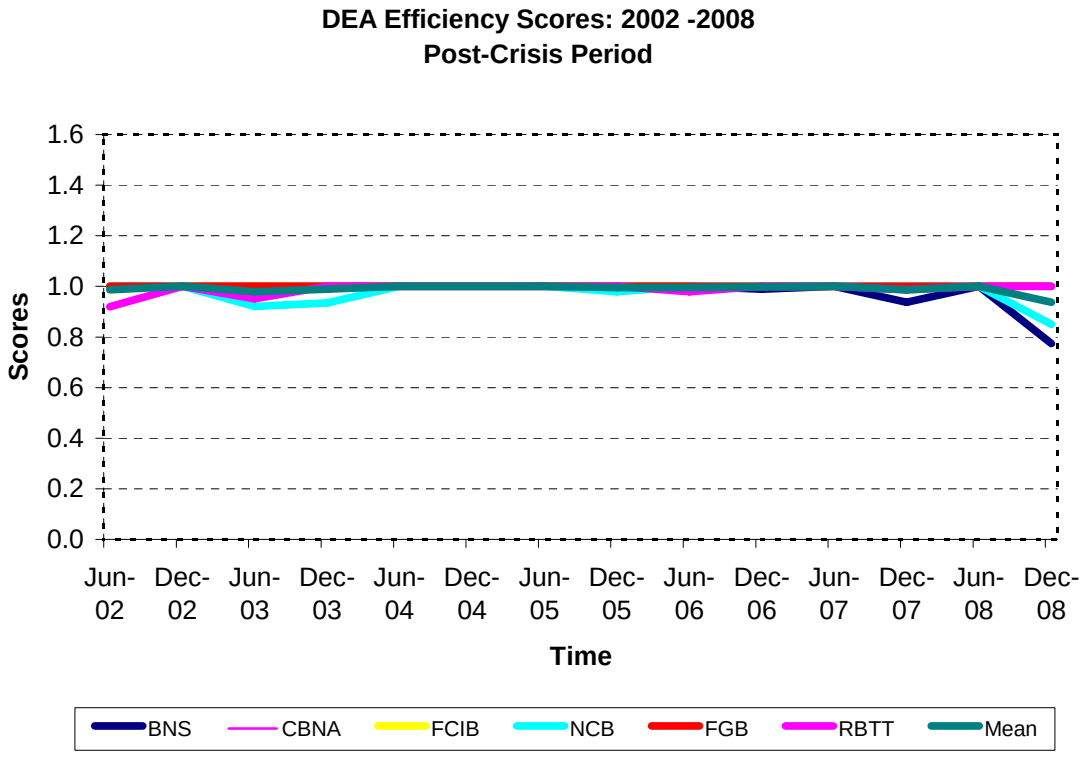


Figure 4.0


DEA Efficiency Scores: 2002 -2008
Post-Crisis Period
Scores
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jun-02
Dec-02
Jun-03
Dec-03
Jun-04
Dec-04
Jun-05
Dec-05
Jun-06
Dec-06
Jun-07
Dec-07
Jun-08
Dec-08
Time
BNS
CBNA
FCIB
NCB
FGB
RBTT
Mean