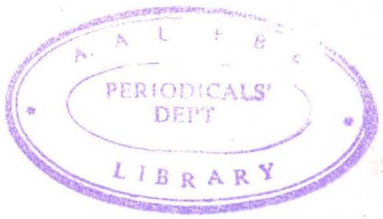

Linking Relative Efficiency and Operating Financial Decisions of Commercial Banks in Ethiopia: Application of Data Envelopment Analysis Model in conjunction with Financial Ratios.

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BY:
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ABSTRACT

Banking institutions perform inter mediation functions and consequently influence the level of money stock through their ability to create deposit liabilities. Therefore, it is critical for depositors, investors, regulators, and the public at large to have vested interest in the performance of banking institutions. Performance evaluation of bank should be linked to decision models so as to associate the results obtained with the decision.

To this end, this study initiated with the objective of accurately classifying the commercial banks in Ethiopia based on their relative efficiency scores has also identified the major financial operating decisions that lead them to better performance. Introducing the Data Envelopment Analysis model is also the purpose of this study. To sum up, the primary purpose is to demonstrate through this empirical evidence that DEA in conjunction with financial ratio analysis can effectively aggregate and reclassify the perplexing ratios into meaningful financial dimensions, which enable us to gain insight into the financial operating strategies of banks.

DEA is the index of sum of weighted outputs to sum of weighted inputs. This model is used to classify six commercial banks in Ethiopia – those have operated in the industry for at least two years before 2000 – based on their relative efficiency scores. While others may not agree with the input and output variables selected in this study for the DEA model, this study uses interest income, non-interest income, and total loans as outputs and Interest expenses, non-interest expenses, and total deposits as inputs. The financial operating decisions like capital adequacy, profitability, asset utilization, and liquidity for 1995 to 1999 are also captured through twelve financial ratios extracted from the banks' financial statements.

*For the purpose of this study efficiency is defined as an 'intermediary approach' which examines the bank's function as a financial intermediary between savers and borrowers. According to the DEA efficiency score derived, this study divides the banks into three categories - **high**, **medium**, and **low** DEA efficiency - for financial peer group analysis.*

The empirical results indicate that those banks with higher DEA scores also have higher ratios in capital adequacy, asset utilization and profitability efficiency, and lower ratios in financial leverage and liquidity than those with lower DEA scores. That is banks with more capital (in a relative magnitude) tended to engage in higher loan risk lending for higher profits; while those with less capital were more conservative in lending money. This shows that the application of DEA in conjunction with financial ratios can not only accurately categorize banks with respect to each other in terms of their DEA efficiencies but can also somehow link the evaluated efficiencies with the bank's actual financial operating decisions.

I. INTRODUCTION

The banking sector in most economies is so critical that it attracts much attention from the public as well as regulatory authorities. According to Sherman and Gold (1985), banking institutions perform inter mediation functions and consequently influence the level of money stock through their ability to create deposit liabilities. Therefore, it is critical for depositors, investors, regulators, and the public at large to have vested interest in the performance of banking institutions.

The driving force for monitoring the performance of banks is to gain an insight into their objectives (Sherman and Gold, 1985). According to Oral and Yolalan (1990), Performance evaluation of bank should be linked to decision models so as to associate the results obtained with the decision. In an attempt to monitor the performance of banks, financial economists have used financial ratios. Yeh(1996) notes that the major demerit of this approach is its reliance on benchmark ratios. These benchmark ratios may not be suitable and thus, can mislead an analyst. Moreover, Oral and Yolalan (1990), note that financial ratios represent short-term measures of operating performance rather than the more relevant long-term performance. According to them, financial ratios are not appropriate because they aggregate many aspects of performance such as operations, marketing, and financing.

The World Bank and IMF jointly have started to assess financial system soundness in their member countries through their program called Financial Sector Assessment Program (FSAP) introduced in May 1999 (Hailers, 2000). They allow for assessments to be based on objective measures of financial soundness. According to their meeting held on January 2000, financial crises often occur when both types of indicators point to vulnerabilities - that is, when financial institutions are weak and face macroeconomic shocks. Indicators of the current health of the financial system are derived primarily by aggregating data on the soundness of individual financial institutions (Hilbers, 2000). The FSAP used framework for analyzing the health of

individual institutions - the CAMELS framework - Which looks at six major aspects of a financial institution: Capital adequacy, Asset quality, Management efficiency, Earnings, Liquidity, and Sensitivity to market risk.

The central Banks of various countries instituted an early-warning performance-based system that uses capital adequacy ratio, loans-to-deposit ratio, liquidity ratio, minimum paid-up capital and sectors credit allocation (Ayadi, 1998). An early-warning mechanism is desirable because it helps regulatory authorities to put in place a redemption program either to prevent a bank from failing or limit the loss to depositors and/ or tax payers of a failing bank (Mauri, 1985). However, none of the aforementioned ratios directly measures managerial ability to convert a set of inputs into a set of outputs (Barr and Siems, 1994).

In the wake of banking distress in different parts of the world, many papers have attempted to determine the quality of bank management and its relationship with banking distress using data envelopment analysis. The results were consistently proved that the weakness of commercial banks is attributed mainly to poor management which manifests in excessive credit and liquidity risk, poor loan quality, sluggish ability to generate capital internally (Sherman and Gold, 1985; Oral and Yolalan, 1990; Yeh, 1996; Ayadi, 1998). Regardless of the joint efforts of World Bank and IMF and efforts of many researchers, the problem of banking distress has continued threatening the economic development of many developing and under developed countries by depressing their banking industry.

Today's competitive banking environment has heightened the need for methods to evaluate the risk and returns involved in banking. This need exists in both industrialized and nonindustralized countries. Currently, bank regulators often use financial ratios of accounting data to screen banks. The National Bank of Ethiopia, for example, found that financial ratios regarding capital adequacy, earnings, liquidity, liability, and growth of savings deposits are useful in evaluating the economic performance and management quality of banks in Ethiopia. Financial ratio

analysis has one disadvantage. That is, each single ratio must be compared with some benchmark ratios one at a time while one assumes that other factors are fixed and the benchmarks chosen are suitable for comparison. To overcome this problem, a number of financial ratios are generally required to be calculated and combined to form a meaningful picture of a firm's financial structure. While the calculation of a set of financial ratios is a relatively easy task, the aggregation of those ratios can be a quite complicated process involving imagination and experienced judgement. Changing economic conditions have made such aggregations even more difficult, increasing the need for a more flexible way to express a bank's financial condition.

A number of studies have attempted to use statistical methods with financial ratios to generate early-warning signals for distressed banking institutions. The idea is to develop meaningful 'peer group analysis', that is, to develop specific financial characteristics that distinguish between two or more groups, for example, failed and non failed banks, or problem and non problem banks, with relatively 'good' or 'bad' financial conditions. However, except when a priori groups are available to provide certain financial profiles for comparisons, identifying appropriate peer groups for analysis is a difficult task. Data Envelopment Analysis (DEA), which computes a firm's efficiency by transforming inputs into outputs relative to its peers, may provide a fine mechanism for deriving appropriate categories for this purpose.

II. PROBLEM AND OBJECTIVES OF THE STUDY

National Bank of Ethiopia (NBE) is the financial regulator that ensures the financial system soundness in the country. Consequently, it is responsible for developing methods which generate early-warning signals for distressed banking institutions in order to secure the society from financial crises. And the public has also the right to know evidently the sustainability of commercial banks while choosing which bank to do business with. Commercial banks perform intermediation functions and

consequently influence the level of money stock through their ability to create deposit liabilities. Therefore, it is critical for depositors, investors, regulators, and the public at large to have vested interest in the performance of commercial banks. Therefore, categorizing commercial banks accurately with respect to each other in terms of their efficiencies and somehow linking the evaluated efficiencies with the bank's actual financial operating decisions help to evaluate performance of commercial banks in different financial dimensions. In addition to the main objective of identifying the financial operating decisions (such as capital adequacy, profitability, asset utilization, leverage, etc) that contribute to high relative efficiency in commercial banks of Ethiopia, the study has also emphasized:

- Introducing the useful management tool - the DEA in conjunction with financial ratios - which allows regulatory agencies (for example, National Bank of Ethiopia) to transform multiple criteria into a scalar efficiency measure to better understand bank inefficiencies to protect the public at large from financial crises.
- Introducing the powerful model - DEA - which can assist examiners like Board of Directors as an early warning tool by providing crucial information about a bank's financial condition and management performance.

III. METHODOLOGY

A. DEA MODEL

i. Historical background and Philosophy

Efficiency analysis has always interested researchers because of the relative difficulty encountered in assessing the performance of a firm or an organization. Using an engineering - like approach, Farrell (1957) attempted to measure the efficiency of a unit of production in the single input-single output case. Farrell's study involved the measurement of price and technical efficiencies and the derivation of the efficient production function.

Farrell applied his model to estimate the efficiency of the US agriculture relative to othe countries. However, he failed in providing a way to summarize all various inputs and outputs into a single virtual input and single output.

In 1980 Charnes, Cooper, and Rhodes extended Farrell's idea and proposed a model that generalizes the single-input, single-output ratio measure of efficiency of a single Decision-Making Unit (DMU) in a multiple-inputs, multiple-outputs setting. A DMU is an entity that produces outputs and uses up inputs. In banking, a bank constitutes a DMU. The technical efficiency of a DMU is computed using the engineering-like efficiency measure of efficiency as ratio of virtual output produced to virtual input consumed:

$$\text{Relative efficiency (Technical efficiency)} = \frac{\sum weigted.OUTPUTS}{\sum weigted.INPUTS}$$

As for the weights used in the transformation of the vectors of inputs and outputs into two single virtual scalars, the DEA model allows each DMU to choose the set of multipliers (weights) μ_o and ν_o that permits it to appear in the best light. The efficiency score obtained is also relative to a sample of DMUs under analysis since the set of weights has to be feasible for other units and none of these units should have an efficiency score greater than one.

In contrast to *regression analysis,* which gives us an average profile of DMUs under analysis, DEA yields a piecewise empirical external production surface that, in economic terms represents the **revealed best practice** production frontier (or envelop). By projecting each unit onto the frontier, it is possible to determine the level of inefficiency by comparison to a single reference unit or a convex combination of other reference units. The projection refers to a virtual DMU which is a convex combination of one or more efficient DMUs. Thus, the projected point may itself not be an actual DMU. The link can be made with Marko Witz's portfolio efficient frontier (1953) idea in which DMUs are supposed to be in some way divisible and that a benchmark, which is a convex combination of other efficient DMUs, can virtually exist. The inefficient DMU is, therefore, supposed to emulate the benchmark's practices in order to become efficient.

ii. An Overview of the DEA Model

DEA is a new powerful mathematical programming approach which measures the relative ratio of a DMU's total weighted outputs to total weighted inputs. Data Envelopment analysis (DEA) is applied to each DMU to determine its measure of transformational efficiency. The index of transformational efficiency is used to proxy the success & quality of management (Yeh, 1996; Barr and Siems, 1994 and Oral & Yolalan, 1990). It should be noted that the DEA approach is a relative measure of efficiency because it compares a firm's observed outputs and inputs and identifies the "best practice" of firm(s) in a group. Each firm in a group is then measured relative to the "best" (virtual) firm.

iii. Input-oriented Models in DEA

The standard DEA model, in ratio form is expressed as follows:

$$\text{Max} \quad \theta_0 = \frac{\sum_i \mu_i \gamma_{i0}}{\sum_j \nu_j \chi_{j0}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Subject to:

$$\frac{\sum_i \mu_i \gamma_{ik}}{\sum_j \nu_j \chi_{jk}} \leq 1 \quad \text{for all DMUs K=1,2,3,…,n.}$$

$$\mu_i \geq 0$$

$$\nu_j \geq 0$$

In the model above, θ_0 is the efficiency score of the DMUo under analysis

I = number of outputs

J = number of inputs

n = number of DMUs under analysis

γ_{ik} = the output i for DMU K.

χ_{jk} = the input j for DMU K.

μ_i = weight for output i

ν_j = weight for input j.

It should be noted that the model represented as equation 1 is a non - linear fractional mathematical programming problem. Charnes et.al (1994) developed an alternative linear programming of the form:

$$\text{Max. } \theta_0 = \sum \mu_i \gamma_{io} \quad \text{.....(2)}$$

Subject to:

$$\sum_j \nu_j \chi_{j0} = 1$$

$$\sum_i \mu_i \gamma_{ik} - \sum_j \nu_j \chi_{jk} \leq 1$$

$$\mu_i \geq \varepsilon$$

$$\nu_j \geq \varepsilon$$

An input-oriented model 2 above can be interpreted as follows. Any DMU "O" has the latitude to choose the set of weights that maximize its efficiency relative to other

DMUs of the sample provided that no other DMU or convex combination of DMU could achieve the same output vector with a smaller input vector. In other words, in an input oriented model, a DMU is not efficient if it is possible to decrease any input without augmenting any other input and without decreasing any output. Mathematically, a DMU is termed efficient if its efficiency rating θ_0 obtained from the DEA model is equal to one. Otherwise, the DMU is considered inefficient. An attempt to impede false technical efficiency was made through the introduction of the small non-archimedian infinitesimal ε to prevent DMUs from giving zero weights to factors that manage poorly. (Charnes et.al., 1994).

Among three possible DEA orientations in efficiency analysis (Charnes et. al, 1994) input-oriented model is used in this paper. The reason is that input-oriented models are used where DMU are deemed to produce a given amount of outputs with the smallest possible amount of inputs. Hence, inputs are controllable in this orientation. In the case of bank efficiency, most inputs are controlled. The model therefore, helps to draw the best efficiency level from the performance of local banks at which income (output) can be maximized manipulating the controllable expenses (input).

DEA as powerful tool can also create problems if not applied with caution. The following limitations are considered when choosing to use DEA.

- DEA is an extreme point technique. Hence, noise such as measurement error can cause significant problems.
- DEA is good at estimating "relative" efficiency of a DMU but it converges very slowly to "absolute" efficiency. In other words, it can tell you how well you are doing compared to your peers but not compelled to a "theoretical maximum".

Except for the aforementioned limitations in mind when using the model, problems like intensive computation of separate linear program created for each DMU are solved by using the LINDO software packages.

iv. Banks input-output data selection to DEA.

This study applies DEA to evaluate the relative efficiency of bank performance in Ethiopia. As suggested by Oral et al(1990) and others, the DEA model seems most meaningful when it is applied to observation sets of units or organizations providing similar resources. By the same argument, it makes sense to compare banks in the services rendered and the resources used. This means that one has to take into consideration the homogeneity requirement before selecting the observation of banks for constructing the DEA model. Deregulation of the bank industry in 1994 has given banks in Ethiopia much more operating flexibility than before, and many new private banks have been founded this, in turn, has dramatically altered the banking environment of Ethiopia. New and old banks are different in many aspects: for example, there is a large distinction in their sizes, branch network, and institutional strength (synergism) and capital amounts. In addition, the operations of old banks have been profoundly affected by deregulation. The DEA model demonstrated in this study uses the financial statements of six commercial banks in Ethiopia for the period from 1995 to 1999. These banks are private and government owned commercial banks in Ethiopia, and had at least ***two or more*** years of banking history before 2000.

Selecting proper input and output variables is perhaps the most important issue in using DEA to measure the relative efficiency of any type of firm, since it determine, the evaluating context of the comparison. This is partially true for banks because there is considerable disagreement over the appropriate inputs and output in this industry. In sum, previous studies generally have adopted one of three approaches to justify their choice of inputs and outputs.

The First approach views banks as service-producing organizations that is organizations which use resources of labor, capital, and equipment to develop such products as payments, loan funding, and other financial services . This approach does not consider the revenue as an output. Studies using this approach have been done by Oral et.al (l992), and by Parkan (1987), for measuring the bank's operational or service efficiency. In particular, in these studies, they have defined bank outputs as the number of accounts, various transactions measured in number or time units, number of loan applications, and customer service survey ratings, etc; bank inputs were defined as rent, capital and operating costs, number of on-line terminals, marketing condition or activity ranking and labor measured in number or as monetary expense, etc. The interest expenses are excluded from the inputs because, in this approach, they are not considered to be expenditures directly generated by the bank operating process.

The second approach, as described by Hancock (1989), uses the simple rule that if it produces revenue it is an output; if it requires a net expenditure, it is an input. In other words, this approach emphasized the profitability of a bank in relation to the various expenditures. Hence the interest expenses are treated as an input to the DEA model under this approach. Specifically, in these studies, as in the one given by Oral et al (1992), for measuring the relative profitability efficiency of a set of bank branches, the banks' outputs are their interest and non-interest income, while their inputs are their interests paid on deposits, as well as expenses of personnel, administration, and depreciation generated by the operation of bank business.

The third approach views banks as financial intermediaries whose primary business is to borrow funds from savers and lend those funds to others for profits. This means the studies under this premise tend to examine the efficiency of essential intermediary functions of a bank. At least two studies adopting this approach have held different viewpoints in their choice of input and output variables. Yue (1992), in a study of 60 commercial banks, defined the banks' outputs as total loans

(measured in dollars), and interest and non-interest incomes; the inputs were defined as the various costs and total deposits. The various costs Yue chose were interest expenses, labor costs, and operating costs. As to why the author selected these inputs and outputs, Yue argued that the performance efficiency of commercial banks should be approached and evaluated in light of their basic financial characteristics. Siems (1992), however, in a study that distinguished a group of failed banks from those that survived, specified a different data set. Bank outputs in Siems' study were deposits, earning assets, and interest income, while the inputs were number of employees, salary expenses, asset values, interest expenses, non-interest expenses, and purchased funds. The main difference between the two studies can be attributed to how 'deposits' and 'purchased funds' were treated. Yue (1992) indicated that deposits and purchased funds are the sources of loanable funds to be invested in asset and hence they both together represent an input in the bank intermediating process. On the other hand, Siems indicated that core deposits are an intermediary output produced by the bank operations, and funds purchased are additional money needed when management has not attracted enough stable or core deposits for the loans it is currently servicing and hence deposits should be an output, while purchased funds should be an input. One might say that Yue places more emphasis on testing the intermediary efficiency performed by a bank, while Siems is primarily concerned with differentiating the qualities of bank management.

In Ethiopia during the period under discussion, bank industry regulation limited investment channels open to private savings to industrial investment, real estate, or simply gold buying. Under such situation, the availability of funds and the costs of deposits would not be major problems to banking institutions. The emphasis on bank management was on making sound lending decisions. That is, instead of offering competitive interest rates on savings accounts to attract stable deposits for credit applications bank managers focused most of their attention on credit analysis to determine a borrower's ability to reply loans, along with collateral evaluation and

documentation screening to protect the bank's financial profits and the deposit payments due, especially adjusting the interest rate paid on deposits and the interest rate charged to loans to secure large profits. In other words, the role played by the banks of Ethiopia during this period was primarily to mediate funds between deposits and borrowers. Such a role is closer to the one proposed by Yue, who viewed banks as intermediates and treated both deposits and funds purchased together as an input to the bank business, since deposits were gained with little effort on the part of the bank, but due to financial regulation. In consideration of the specific function and the data collection problem (It is difficult to collect physical data regarding service ranking, number of employees, and number of equipment, etc., from the financial information available to the public), Yue's model was adopted in this study to develop the put and output variables for the DEA test.

Bank outputs used in this study are: (1) interest income; (2) non-interest income; (3)total loans. Interest income includes interest on loans, income from lease-financing receivables, as well as interest and dividend income on securities. Non-interest income includes service charges on loans and transactions, income from renting and fiduciary activities, commissions and other operating income. Total loans consist of loans, and drafts and leases net of unearned income. These outputs represent bank revenues and major profit-making business activities. Bank inputs employed are (1) interest expenses; (2) non-interest expenses; (3) total deposits . Interest expenses include expenses for deposits and other borrowed money. Non-interest expenses include service charges and commissions, expenses associated with fixed assets and general management affairs, salaries, and other expenses. Total deposits are deposits and purchased funds. These inputs represent the costs of labour, administration, equipment and funds purchased for bank operations, and the source of loanable funds for investment.

B. FINANCIAL RATIO ANALYSIS IN BANKS.

Traditionally, banks have used profitability measures as a basis for their performance assessment, while neglecting other non-financial measures such as productivity and quality. However, in the past few years, these practices have started to change towards benchmarking programs based on productivity and quality (Bar and Siems, 1994). Although the value of such programs is now widely accepted within the industry, traditional analytical techniques used in practice are generally not very effective, mostly because of the size and complexity of the processes (Schaffnit and et.al.,1997).

The most widespread of these techniques is perhaps performance ratio analysis, in which a multitude of ratios are used to capture different dimensions of the process. Financial ratio analysis has one disadvantage. That is, each single ratio must be compared with some benchmark ratios one at a time while one assumes that other factors are fixed and the benchmarks chosen are suitable for comparison. To overcome this problem, a number of financial ratios are generally required to be calculated and combined to form a meaningful picture of a firm's financial structure. While the calculation of a set of financial ratios is a relatively easy task, the aggregation of those ratios can be a quite complicated process involving imagination and experienced judgement. Changing economic conditions have made such aggregations even more difficult, increasing the need for a more flexible way to express a bank's financial condition. A wide variety of financial ratios are commonly calculated to assess different characteristics of a bank's performance. Different regulators are accustomed to different screening criteria. In general, the key ratios used to test vulnerabilities and soundness of banks by bank analysts and regulatory authorities of different countries like Taiwan, Europe countries, USA, Nigeria, Kenya, Ghana, and IMF Financial Sector Assessment Program (FSAP) were Profitability, Capital adequacy, Asset quality, Operating efficiency, Liquidity,

and Interest sensitivity. Yeh (1996) has used the following twelve financial ratios too assess these different characteristics of bank's performance.

1. Cash and due from depository institutions/Total deposits;
2 Total deposits/Net worth;
3. Total liabilities (including total deposits, interest payable, dividends and other liabilities)/ Net worth;
4. Net worth/Total loans; (loan service given to customers)
5. Net income before taxes/Total operating income (including interest and non-interest expenses), i.e. profit margin;
6. Net income before taxes /Total assets; (The six ratios above are available in public income and financial statements)
7. Net income before taxes/Net worth, i.e. the rate of return on equity, which is particularly important because the ultimate objective of bank management should be to maximize share holder wealth;
8. Net worth/Total assets, known as the equity multiplier indicating the extent to which the bank is using financial leverage;
9. Interest income minus interest expenses/Total assets, i.e. the net interest margin (NIM) (Since interest income and expenses make up the lion's share of total operating income and expenses, respectively NIM is well worth calculating);
10. Total operating income (including interest and non-interest income)/Total assets, representing the ability of management to employ assets effectively to generate revenues;
11. Total loans/Total assets, i.e. the loan risk ratio, indicating the extent to which assets are devoted to loans as opposed to other assets, including cash, securities, and plant and equipment;
12. Total loans/ Total deposits, a common ratio for measuring the bank liquidity and the degree to which bank's deposits are devoted to loans in comparison with other liabilities and net worth.

The popularity of these ratios lies perhaps in their simplicity and ease of calculation. Clearly, however, each of these ratios gives only a one dimensional incomplete, picture of the process. Moreover, According to Yeh (1996), each ratio fails to account for the interactions, and the trade-off, between the different players and factors in the process. The final result is often a multitude of partial, often contradictory, measures that management must try to combine to get an overall picture of performance (Schaffnit & et.al, 1997).

C. INCORPORATING DEA WITH FINANCIAL RATIO ANALYSIS.

Financial ratios of accounting items permit a historical sketch of bank returns and risks. Bank performances and operational strategies can be assessed through the comparison of financial ratios with peer group banks. To examine the differences in financial performances between banks with different DEA scores in connection with the available financial information, the banks in the test are classified into three groups-***high***, ***medium***, and ***low*** - in accordance with their respective DEA efficiency scores.

Yeh (1996) has used twelve financial ratios classified into five groups to summarize and identify a set of sustained dimensions that are not easily observed in a large data set. This study also adopt the twelve financial ratios classified in five groups as follows:

- Group 1. Capital Adequacy
  - ↘ Net worth/Total Assets
  - ↘ Net worth/Total loans
- Group 2. Financial Leverage
  - ↘ Total Liabilities/Net worth
  - ↘ Total deposits/Net worth

- Group 3. Profitability
  - ↘ Net income before taxes/Net worth
  - ↘ Net income before taxes/Total assets
  - ↘ Net income before taxes/Total operating income
- Group 4. Asset Utilization
  - ↘ Interest income minus interest expense/Total assets
  - ↘ Total loans/Total assets
  - ↘ Total operating income/Total assets
- Group 5. Liquidity
  - ↘ Cash + due from depository institutions/total deposits
  - ↘ Total loans/Total deposits

Each of the above ratios contribute additional information needed to measure a bank's financial condition, together they are a morass of numbers which don't easily lend themselves to an overall judgment. A classification of the ratios based on their financial attributes can help specify their respective implications and determine whether the ratios examined adequately express a firm's financial profile.

IV. EMPIRICAL RESULTS

The DEA efficient scores are summarized in Table 1, where each score is referred to by the year and bank evaluated with banks represented alphabetically as A to F (to keep the bank's names confidential). The average DEA scores for each bank and each year are also reported. It can be seen from Table 1 that, of all the banks, bank B was the most DEA efficient followed by bank C and A; bank E was the least DEA efficient.

The results show that Bank B consistently recorded an index of 1.00 in 1997 through 1999. Bank A on the other hand recorded an index of 1.00 in 1995 and 1996. On the year-by-year basis, the relative efficiency scores range from 0.95 to

1.00 in 1995, 0.94 to 1.00 in 1996, 0.83 to 1.00 in 1997, 0.79 to 1.00 in 1998, and 0.88 to 1.00 in 1999. The largest range between the relative efficiency scores is 0.26 which was recorded in the year 1998 when the economy was under the pressure of the Ethio-Eritirean war. In 1995, only one of the two banks is classified as efficient - Bank A. The same Bank A among three banks has scored full relative efficiency in 1996 also. In 1997, however, Bank B and C have become efficient among five banks operating at the time. In 1998 and 1999 only one bank of the six banks (bank B) is classified as efficient. As noted earlier, Bank b is consistently rated efficient regardless of the two years -1995 and 1996- which were the establishment periods as a new entrant to the industry.

Table 1 also shows that the DEA scores generally decreased between the year 1995 and 1998, then started to increase. In particular, the average DEA efficiency score of the banking industry in the country reached its lowest level of 0.83 and 0.79 in 1997 and 1998 respectively. This trend almost coincided with the drop in the business cycle that occurred in Ethiopia in 1997 and 1998, perhaps indicating the influence of the Ethio-Eritirean war on economic conditions and banking business. These results seem to confirm the validity of DEA in evaluating bank performances with an emphasis on the essential intermediary functions of a bank.

One can see from Table 1 that there are a total of 22 DEA efficiency scores with regard to the operations of the six banks in 5 years. To discriminate the financial conditions among these banks and years with different DEA scores, the 22 banks/year combinations were classified into three groups according to their DEA efficiency scores: 1 for the high DEA group (6 scores), 0.99 - 0.85 for the medium DEA group (11 scores), and 0.84 -0.65 for the low DEA group (5 scores) for subsequent peer group analysis.

The 12 financial ratios are consistent and accessible to interpretation (Yeh, 1990). These ratios are adopted and their associated financial ratios by DEA efficiency group are reported in Table 2. As shown in Table 2, Group 1 refers to the ratios for

measuring the adequacy of bank capital, Group 2 measures extent to which the banks used financial leverage to generate their assets, and are thus named 'Capital Adequacy and financial leverage respectively; Group 3 refers to the ratios of net income to capital, assets, and total operating income, respectively, and is thus named 'profitability'. Group 4 refers to the measurements of the degree to which assets were used by the banks to produce net interest income, total income, and loans, and is thus named 'Asset Utilization', Group 5 refers to the ratios for assessing the extent to which the banks had funds available to meet cash demands for deposit withdrawals, and the degree to which total deposits were drawn by the bank for the volume of loan's it was servicing, and is thus named 'Liquidity'. In general, these four dimensions are consistent with the key ratios commonly used by bank analysts in Ethiopia to monitor banks' financial conditions and generate early-warning signals for distressed banks.

TABLE 1. DEA efficient scores of the six Banks in the test in years 1995-1999

	1995	**1996**	**1997**	**1998**	**1999**	**Average**
Bank A	1.00	1.00	0.86	0.80	0.90	0.91
Bank B	0.95	0.98	1.00	1.00	1.00	0.99
Bank C	-	0.94	1. 00	0.99	0.98	0.98
Bank D	-	-	0.93	0.84	0.94	0.90
Bank E	-	-	0.83	0.79	0.89	0.84
Bank F	-	-	-	0.81	0.88	0.85
	0.98	0.97	0.92	0.87	0.93	-

TABLE 2. Mean financial ratios and their differences between DEA groups

	High (N=6)	Medium (N=11)	Low (N=5)
DEA Efficiency Score	1	0.99-0.85	0.84-0.65
Group 1-Capital Adequacy			
Net worth/Total assets	0.062	0.056	0.041
Net worth/Total loans	0.093	0.080	0.053
Group 2 -Financial Leverage			
Total liabilities/Net worth	16.554	18.711	26.792
Total deposit/Net worth	15.701	16.532	24.858
Group 3-Profitability			
Net income before taxes/Net worth	0.288	0.284	0.264
Net income before taxes/Total assets	0.017	0.016	0.011
NI before taxes/Total operating income	0.189	0.195	0.162
Group 4 -Asset Utilization			
Interest income minus interest expenses/Total asset	0.075	0.067	0.059
Total loans/Total assets	0.074	0.720	0.614
Total operating income /Total assets	0.095	0.084	0.071
Group 5-Liquidity			
Cash + due from depository institution/Total deposits	0.165	0.185	0.202
Total loans/Total deposits	0.953	0.902	0.724

Table 2 shows that the banks in the groups with higher DEA scores also have various higher ratios in capital adequacy, asset utilization and profitability, and lower ratios in financial leverage and liquidity (or say, higher ratios of loans to deposits), than those with lower DEA scores, except that the profit margin of the high DEA group is a little smaller than that of the medium DEA group. Specifically, banks with high DEA efficiency scores have higher ratios of 0.062 and 0.093 in Net worth/total assets and Net worth/total loans respectively and lower ratios of 16.554 and 15.701 in total liabilities/net worth and total deposit/net worth respectively.

Similarly, in the profitability factor they have higher ratios of .288 and 0.017 in earning capacity of net worth and total assets respectively. However, the high DEA group has a profit margin ratio of 0.189 which is a little lower than the medium DEA group profit margin ratio of 0.195.

Furthermore, the net interest margin, the total operating income/total assets, and loan risk ratios are 0.075, 0.074, and 0.095 for high DEA group respectively. These ratios are higher than both medium and low DEA groups. With regard to liquidity, the idle liquid cash generated from deposits for high DEA group is lower than that of the medium and low DEA groups. This is confirmed by the high DEA group ratio of 0.165 which is lower than that of the medium and low DEA group ratios of 0.185 and 0.202 respectively. In contrary, the ratio for measuring the bank liquidity and the degree to which bank's deposits are devoted to loans of high DEA group is 0.953. And this ratio is higher than the DEA medium and low groups ratio of 0.902 and 0.724. This result seems to indicate that these banks that performed more efficiently in extending the financial intermediary function as given in the DEA model, in relation to their net worth, assets, and operating costs, also earned more income for profits, and utilized their assets more efficiently, while they had lower liquidity, than those that were less efficient.

V. SUMMARY and CONCLUSIONS

A. Summary

- The banks in the groups with higher DEA scores have various higher ratios in capital adequacy, asset utilization, and profitability than those with lower DEA scores.
- The banks in the groups with lower and medium DEA groups have higher ratios in financial leverage and liquidity than those with higher DEA scores.
- The profit margin of the high DEA group is a little smaller than that of the medium DEA group.

- In relative magnitude, the banks which had larger net worth or smaller financial leverage tended to invest more funds in loans and make higher utilization of their assets to produce more revenues, and such a financial operation decision makes them rank high in DEA efficiencies.
- The DEA efficiency score of banks in Ethiopia reached its minimum level in 1998 when the economy was perhaps under pressure of the war.
- DEA measures banks performance efficiency and financial ratios indicate the financial operating decisions made to achieve the observed performance. The link helps to gain insight into their strategies, objectives, and critical activities.

B. Conclusions

Financial ratios have been used as a cost efficient and convenient way to keep track of bank's financial condition. However, when several non-aggregated single input-output ratios are used at one time, there is no clear-cut rationale for using one combination of ratios over any other to obtain an overall composite score. Through an empirical study of bank management in Ethiopia during 1990s, this paper demonstrates how the use of DEA in conjunction with financial ratio analysis can help to aggregate the puzzling ratios into meaningful dimensions that somehow link with the financial operating strategies of a bank. From this particular application, the following conclusions can be drawn:

1. By considering the major function of financial intermediation as the input-output criterion for bank performance evaluation, the results highlighted by the financial ratio analysis show that banks which were more DEA efficient were less leveraged and more aggressive in employing their deposits and assets to generate revenues than those who were less DEA efficient. These data indicate that the conjunction of DEA with financial ratios is a useful management tool which allows financial analysts to transform multiple criteria into a scalar

efficiency measure to better understand bank inefficiencies with respect to the multiple input-output objectives defined in the DEA model.

2. The trend of each bank's DEA efficiency score over time reflected the business cycle which occurred in Ethiopia during 1995 to 1999, revealing that external economic conditions affect bank performance. This result indicates that DEA trends over time may provide valuable information about bank performance.
3. Although DEA has fewer limitations than other econometric approaches in the choice of input and output variables, the efficiency measure obtained by DEA is sensitive to the combination of inputs and outputs. For example, the combination of inputs and outputs in this study emphasizes the bank's intermediary function and thus, as illustrated by the financial ratio results, the DEA efficiency score is determined primarily by the bank's lending actions. Therefore, one must carefully select the input and output variables to make the analysis useful and implemented.
4. No distinction can be made among the banks with DEA efficiency score of 1. However, increasing the entire population of banks in the test may help eliminate this problem since DEA provides better contrast in comparing units with respect to their efficiency when the number of units is significantly larger than the sum of the number of inputs and outputs considered.
5. In general, if the inputs and outputs are properly chosen, DEA can provide crucial information about a bank's financial condition and management performance. Although DEA may not be able to replace an examiners' on-site evaluation of a management, it can assist examiners as an early-warning tool. Ethiopia is striving to establish and promote efficient and competitive banking industry in the country. To attain this goal, National Bank of Ethiopia, Board of Directors of Bank's, and Government officials have to now search for alternative management tools to effectively quantify bank performance, and DEA in conjunction with financial ratio analysis is a tool worthy of consideration.

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