An Analysis of Bank Efficiency and Stock Prices Using Data Envelopment and Stochastic Frontier Analysis Models

Owen Jakata¹, Farikayi K. Mutasa²

Abstract

This study investigated how stock prices and bank efficiency are linked to shareholder value creation. In this study two models Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) are applied to estimate bank efficiency. A comparative efficiency analysis of the two models, DEA and SFA was done and it was concluded that the two methods are consistent in terms of the results that were obtained. The difference between DEA and SFA efficiency scores is due to the presence of measurement error in DEA model and due to the functional form of the SFA model. The two methods are used jointly to provide complementary information. The banks were ranked in terms of efficiency scores and CBZ and FBC were ranked number one and two respectively. In this study sensitivity analysis was used to determine which factors between bank efficiency, log Total Assets, ROE and ROA have the greatest influence on stock prices. The results show that bank efficiency has the greatest influence on stock prices as compared to the traditional accounting measures of performance. We conclude that any improvements in bank efficiency will result in improvements in shareholder's value which is inferred in improved stock prices.

Keywords: Bank efficiency, stock prices, data envelopment analysis, stochastic frontier analysis, Zimbabwe Stock Exchange.

1. Introduction

Zimbabwe, once a fast growing Southern African country experienced a serious economic downturn with increasing high levels of unemployment and declining economic fundamentals between 1997 and 2008. The country was confronted with a contracting per capita income, declining Growth Domestic Product (GDP), increasing imports, decreasing exports, increasing interest rates, serious pressures on the currency, rising inflation and declining dollar value. The shrinking economy and high inflationary levels in turn forced a number of firms and a chain of banks to shut down. This negatively affected economic performance and investor confidence and resulted in high levels of uncertainty in the banking sector and other sectors.

At the height of the economic meltdown and hyperinflation, Zimbabwe experienced a chain of bank closures in 2004. The latest bank closures in 2012 of Interfin Bank and Genesis Bank shows that the economic problem is still evident even if the economic environment has changed. There is no doubt that banks are partly battling for survival due to poor economic performance, low capacity utilization by industry and depressed demand against a backdrop of low disposable incomes. These banks are also struggling because of tight liquidity conditions in which they operate, mainly attributable to volatile short-term transitory deposits and limited lines of credit. There is also a problem of low net income against high operating costs and low capitalization. There are also other factors why banks are not performing well which include poor corporate governance. The authorities need to control and curb these problems in order to save the banking sector from plunging into turmoil.

¹Department of Statistics and Operations Research National University of Science and Technology Ascot, Bulawayo, Zimbabwe
²Department of Applied Mathematics National University of Science and Technology Ascot, Bulawayo, Zimbabwe
As a result of the unstable economic business environment, local and foreign investors have taken a cautious approach towards investing on the Zimbabwe Stock Exchange (ZSE). Investors have not totally deserted the market as they remain keen on the ZSE. This uncertainty in the ZSE has resulted in shareholders and investors being interested in knowing which stocks are performing well and their rankings in terms of the efficiency scores and share performance. In view of the waning investor confidence, investors are now trading cautiously and would want to use multi-criteria decision making models which are more robust than the traditional accounting ratios in measuring and evaluating efficiency scores and performance. This will enable them to make sound decisions on their investments.

The efficiency of individual banks in providing services to the market determines the efficiency of the overall banking sector which in turn influences the effectiveness of the domestic financial services. A banking sector's efficiency can be represented by the average efficiency of its individual banks. Efficiency in the banking sector is recognized as a precondition for macroeconomic stability and important for effective monetary policy execution. In addition the banking sector's ability to allocate credit efficiently is expected to have positive implications for economic growth. In this study we investigated the relationship between stock returns and efficiency of banks listed on the Zimbabwe Stock Exchange (ZSE).

The concept of measuring bank efficiency falls into three categories, namely revenue, cost and profit efficiency. In this study we use profit efficiency to measure bank efficiency since the performance measure will be done considering the views of the shareholders and investors.

There are several approaches which can be used to measure bank efficiency scores. In this study we used Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) to measure bank efficiency. The DEA and SFA models are alternative measures of bank efficiency which explain bank efficiency better than traditional financial ratios in accounting. According to Christos et al., it is accepted in literature that bank efficiency derived from parametric and non-parametric approaches have advantages over the traditional accounting measures of performance.

The decision to purchase a stock or invest in a stock can be difficult since there are many attributes to consider. Some of these attributes may include the commonly used traditional financial ratios which are return on investment, earning per share, price to earnings ratio, return on capital employed, stock turnover ratio, payout ratio, dividend yield and debt ratio. While some shareholders and investors might be more concerned with minimizing the level of risk in their portfolio, others may be more concerned with a high return on investment. It is challenging to measure the overall efficiency of a process when such a process is a multi-output and multi-input process. Since the decision to purchase stock can include the necessary examination of several attributes of inputs and outputs, it can be thought of as a multi-criteria decision-making problem. DEA and SFA models are multi-criteria decision making models that are the most favorable when it is necessary to consider several attributes of inputs and output. These models help to minimize the complexity of analysis by simultaneously evaluating the attributes of interest and presenting a single composite score referred to as efficiency.

The aim of the study is to investigate how stock prices and bank efficiency are linked to shareholder's value creation. The objectives of the study are to formulate the DEA and SFA models, estimate bank efficiency using formulated DEA and SFA models, rank the banks using estimated DEA and SFA bank efficiency, make a comparative efficiency analysis between DEA and SFA models, determine the relationship between stock prices and bank efficiency, determine the relationship between stock prices and bank efficiency whilst controlling for Return on Equity (ROE), Return on Assets (ROA) and Total Assets (TA).

The study will be useful to investors, brokers, stock market regulators, students of finance, government and many other participants on the ZSE. The study is also of great importance to investors planning portfolios and those seeking to appraise the function of the capital markets. The study will enable the investors in the banking sector to determine the kind of the relationship between bank efficiency and stock prices. This will enable them to make sound decisions when investing on the stock market. Researchers, investors, creditors and other users will use the bank efficiency scores to rank the banks in relation to their
efficiency scores, policy makers in the formulation of the necessary regulations to guide the RBZ in drafting a regulatory framework by using efficiency scores and stock prices to guide commercial banks in enhancing their operational efficiency, stock market regulators, investment banks and fund managers with information to guide investors who are interested in buying shares of banks listed on the ZSE, the banking sector with the general trend for bank efficiency for the period 2009 to 2013.

In this study we used the most recent observations of the ZSE covering the period after dollarization of the Zimbabwean economy from January 2009 to December 2013. The results of this study were compared with findings of the previous studies that were performed in other emerging and developed markets around the world. The study is limited to the banks listed on the ZSE. The data collected from these selected banks is used to determine the DEA and SFA efficiency scores. The bank stock prices data was collected from financial statements of all the listed banks.

2. Research Models

In this study three models namely DEA, SFA and regression analysis are used. The regression analysis model is used determine the which factors between Bank Efficiency, Total Assets, Return on Equity and Return on Assets have the greatest impact on stock prices. The two models used to estimate bank efficiency are the:

i) Non-parametric approach which uses linear programming techniques called the DEA model.

ii) Parametric approach and uses the econometric approach called the SFA model.

These two models which are used to determine the bank efficiency of the banks listed on the ZSE. The stock prices are then regressed against bank efficiency in order to establish if there is a statistical link to explain bank stock price changes.

Data Envelopment Analysis (DEA) Model

In Data Envelopment Analysis, the objective is to maximize the composite efficiency of each decision making unit. In this case, the decision-making units are individual banks. The objective of this study is to measure the overall bank efficiency of each bank relative to other units in the data set. The Input Oriented Charnes, Cooper-Rhodes (CCR) Model was applied in this study. This formulation was developed by Charnes et al., (1978), using the DEA linear programming model. The focus is to optimize the ratio of outputs to inputs by solving for a group of weights that satisfy a system of linear equations. The input minimizing programme (using duality in linear programming) which is used in this study is as follows for bank 0 in the sample of n banks is shown in equation (1).

\[
\text{Minimize } h_0 = Z
\]

Subject to
\[
\sum \lambda_j X_{ij} \leq X_{i0}, \text{ Z for } j = 1, \ldots, n, \\
\sum \lambda_j Y_{rj} \geq Y_{r0} \text{ for } j = 1, \ldots, n,
\]

where,
\[
\lambda_j \geq 0, j = 1, \ldots, n
\]

\[
\lambda_j \text{ Are weights on units sought to form composite unit to outperform } j_0,
\]

\[
Z \text{ is the efficiency score,}
\]

\[
X_{i0} \text{ and } Y_{r0} \text{ are known inputs and outputs.}
\]

The input-orientation in the DEA model addresses the question on how much input quantities can be proportionally reduced without changing the output quantities produced. The weighted combination of inputs over outputs therefore forms a production frontier. The bank which lies on the frontier having efficiency score of one and using the reference weight of the reference bank are called peers of the reference bank.

Stochastic Frontier Analysis Model

According to Farallel (1957), the parametric frontier was specified as follows
\[ y_i = f(x_i, \beta) \, \text{TE}_i \]  \hspace{1cm} (2)

where, 
\[ i = 1, 2, 3 \ldots n \] represents the corresponding produce is the level of output, 
x refers to vector of \( n \) inputs, 
\[ f(x_i, \beta) \] is a production frontier depending on inputs and technology parameters \( \beta \) to be estimated, 

\( \text{TE}_i \) is the technical efficiency of the \( i^{th} \) bank calculated as the ratio of observed output over maximum feasible output.

\[ \text{TE}_i = \frac{y_i}{f(x_i, \beta)} \]  \hspace{1cm} (3)

Aigner and Chu (1968) reformulated the frontier function above with the log linear Cobb Douglas production function:

\[ \ln y_i = \beta_0 + \beta_n \ln x_n - u_i \]  \hspace{1cm} (4)

Aigner \textit{et al.}, (1977) put forward another formula that would capture the effects specific to the firm and another random variable that would represent any statistical noise or measurement errors

\[ \ln y_i = \beta_0 + \beta_n \ln x_n + v_i - u_i \]  \hspace{1cm} (5)

where,
\( \ln y_i \) represents the observed output,
\( x_n \) is the vector of the given input,
\( \beta_n \) is the vector of unknown parameters,
\( u_i \) captures the technical inefficiency,
\( v_i \) captures the effects of statistical noise such as the random effects,
\( \epsilon_i = v_i - u_i \) is the error term with a specific distribution.

Technical Efficiency can be calculated by

\[ \text{TE}_i = \frac{y_i}{\exp(x_i, \beta) + v_i} = \exp(-u_i) \]  \hspace{1cm} (6)

Richmond (1974) suggested that the parameters of the Cobb-Douglas production function defined by equation (5) and can be estimated by the Corrected Ordinary Least Squares Regression (COLS). The half normal distribution in Stata (Version 12) is employed to estimate the parameter \( u_i \) which is used to determine the bank efficiency scores. The software program assumes a linear functional form. Therefore to estimate a Cobb-Douglas Production function frontier all the inputs and outputs should be logged as in equation (5).

**Regression Models**

According to Beccalli \textit{et al.}, (2008) they examined the relationship between bank stock prices and bank efficiency. They regressed bank stock prices against bank efficiency, total assets, return on assets and return on equity. The estimated regression models are:

\[ R_{jt} = \beta_0 + \beta_1 E_{jt} + \epsilon_{jt} \]  \hspace{1cm} (7)

\[ R_{jt} = \beta_0 + \beta_1 E_{jt} + \beta_2 \ln \text{Assets} + \beta_3 \text{ROA} + \beta_4 \text{ROE} + \epsilon_{jt} \]  \hspace{1cm} (8)

where,
\( R_{jt} \) – return on the \( j^{th} \) stock for annual return period ending at time \( t \),
\( E_{jt} \) – either the bank \( j^{th} \) annual percentage change in efficiency (DEA and SFA),
Total Assets- natural logs of total assets,
ROE – annual percentage change in return on average equity,
ROA – annual percentage change on return on assets,
\( \epsilon_{jt} = u_{jt} + v_{jt} \), error term.

Model 7 was used to determine the extent to which estimated bank efficiency changes influences the changes in stock performance.
Model 8 was controlled for factors that influence bank stock prices, such as log of total assets for the influence of bank size, the annual change in ROA for risk measure, and the annual change in ROE for profitability.

In this study we used model (7) and (8) to determine how stock prices and bank efficiency are linked to shareholder value creation.

**Software Packages**

Statistical software (Stata Version 12) is used to measure the profit inefficiency parameter $u_i$ which is used to determine the bank efficiency scores. Lingo (Version 9.0) is a statistical programming software tool designed to efficiently build and solve linear, non linear and integer optimization models. This software was used to estimate DEA efficiency scores. Minitab was used to regress stock prices against bank efficiency, total assets, return on equity and return on assets. The three statistical packages which were used in data analysis:

i) Stata (Version 12) was used to estimate SFA parameter $u_i$.

ii) Lingo (Version 9.0) was used to estimate DEA bank efficiency.

iii) SPSS (Version 16.0) was used for regression analysis.

### 3. Data Presentation and Analysis

The efficiency scores are estimated using the formulated DEA and SFA models. The DEA efficiency scores are estimated using statistical software Lingo Version 9.0. The estimations are shown in Table 1 and 2. The SFA efficiency scores are estimated using STATA Version 12. STATA is used to estimate the inefficiency parameter $u_i$ which is used to determine efficiency scores. The inefficiency parameters are used to estimate the SFA model bank efficiency scores using equation (6). The stock prices extracted from financial statements are shown in Table 3.

<table>
<thead>
<tr>
<th>DMU</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012 Interim</th>
<th>2012</th>
<th>2013 Interim</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DEA</td>
<td>DEA</td>
<td>DEA</td>
<td>EA</td>
<td>EA</td>
<td>EA</td>
</tr>
<tr>
<td>Barclays</td>
<td>0.2644</td>
<td>0.00</td>
<td>0.667</td>
<td>0.772</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>CBZ</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.845</td>
</tr>
<tr>
<td>FBC</td>
<td>0.230</td>
<td>0.501</td>
<td>1.000</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>NMB</td>
<td>0.000</td>
<td>0.000</td>
<td>0.613</td>
<td>0.770</td>
<td>0.623</td>
<td>0.423</td>
</tr>
<tr>
<td>ZB</td>
<td>0.000</td>
<td>0.000</td>
<td>0.964</td>
<td>0.700</td>
<td>0.902</td>
<td>0.507</td>
</tr>
<tr>
<td>Mean</td>
<td>0.2500</td>
<td>0.462</td>
<td>0.849</td>
<td>0.888</td>
<td>0.906</td>
<td>0.955</td>
</tr>
</tbody>
</table>

Table 1 shows the DEA estimated efficiency scores for the five listed banks from 2009 to 2013. There was an increase of DEA efficiency scores from 2009 to 2013 for all the banks. Barclays Bank had an efficiency score of zero in 2009. NMB and ZB had efficiency scores of zero in 2009 and 2010. CBZ is the only bank which was highly efficient with efficiency scores of one from 2009 to 2012 but its efficiency score went down to 0.845 in the interim year 2013. The efficiency scores for all the banks in the transition period from the Zimbabwean dollar to the United States dollars are very low. However, the DEA efficiency scores started increasing in the period 2011 to 2013.
Table 2: SFA efficiencies for five listed banks for years 2009-2013

<table>
<thead>
<tr>
<th>DMU</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012 Interim</th>
<th>2012</th>
<th>2013 Interim</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SFA</td>
<td>SFA</td>
<td>SFA</td>
<td>SFA</td>
<td>SFA</td>
<td>SFA</td>
</tr>
<tr>
<td>Barclays</td>
<td>0.497</td>
<td>0.667</td>
<td>0.98386</td>
<td>0.999999839</td>
<td>0.98255</td>
<td>0.97447</td>
</tr>
<tr>
<td>CBZ</td>
<td>0.946</td>
<td>1.000</td>
<td>0.98388</td>
<td>0.999998417</td>
<td>0.98251</td>
<td>0.97437</td>
</tr>
<tr>
<td>FBC</td>
<td>0.504</td>
<td>1.000</td>
<td>0.98417</td>
<td>0.99998411</td>
<td>0.98280</td>
<td>0.97489</td>
</tr>
<tr>
<td>NMB</td>
<td>0.271</td>
<td>0.395</td>
<td>0.98376</td>
<td>0.245</td>
<td>0.98238</td>
<td>0.97404</td>
</tr>
<tr>
<td>ZB</td>
<td>0.000</td>
<td>0.000</td>
<td>0.98404</td>
<td>0.000019776</td>
<td>0.98247</td>
<td>0.97435</td>
</tr>
<tr>
<td>Mean</td>
<td>0.513</td>
<td>0.531</td>
<td>0.98384</td>
<td>0.6449003288</td>
<td>0.98252</td>
<td>0.97442</td>
</tr>
</tbody>
</table>

Table 2 shows the SFA estimated efficiency scores for the five listed banks from 2009 to 2013. There is an increase of SFA efficiency scores from 2009 to 2013 for all the banks. FBC had an efficiency score of zero in 2009. ZB had an efficiency score of zero for 2009 and 2010. CBZ had average efficiency scores of above 0.9 from 2009 to 2013. The efficiency scores for all the banks in the transition period from the Zimbabwean dollar to the United States dollars are very low. However, the SFA efficiency scores started increasing in the period 2011 to 2013.

Table 3: Stock Prices for five listed banks for years 2009-2013

<table>
<thead>
<tr>
<th>DMU</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012 Interim</th>
<th>2012</th>
<th>2013 Interim</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barclays</td>
<td>0.500</td>
<td>7.00</td>
<td>7.500</td>
<td>9.000</td>
<td>10.500</td>
<td>12.000</td>
</tr>
<tr>
<td>CBZ</td>
<td>15.00</td>
<td>18.00</td>
<td>19.000</td>
<td>20.400</td>
<td>26.000</td>
<td>12.000</td>
</tr>
<tr>
<td>FBC</td>
<td>1.850</td>
<td>3.50</td>
<td>5.000</td>
<td>6.500</td>
<td>7.500</td>
<td>12.000</td>
</tr>
<tr>
<td>NMB</td>
<td>1.000</td>
<td>1.10</td>
<td>1.380</td>
<td>2.125</td>
<td>2.650</td>
<td>3.00</td>
</tr>
<tr>
<td>ZB</td>
<td>12.00</td>
<td>14.00</td>
<td>18.00</td>
<td>20.000</td>
<td>13.000</td>
<td>25.000</td>
</tr>
</tbody>
</table>

Table 3 shows stock prices for the period 2009 to 2013 for all the listed banks. There is a gradual increase in stock prices for all the banks over the period concerned although there was a decrease in the stock price return for CBZ to 12c in the interim year 2013. These stock price returns are regressed against DEA and SFA efficiency scores.

Comparative Efficiency Analysis

This section compares efficiency scores of the DEA and SFA models. A comparative efficiency analysis is used to determine the roles of the main strengths and limitations underlying each model to the differences in the efficiency scores. The DEA and SFA mean bank efficiency for each bank for the period 2009 to 2013 shown in Table 4. The rankings for each bank over the period 2009 to 2013 are also shown in Table 4.

Table 4: Mean Bank Efficiency for each bank over the period

<table>
<thead>
<tr>
<th>DMU</th>
<th>DEA Bank Efficiency</th>
<th>DEA Rank</th>
<th>SFA Bank Efficiency</th>
<th>SFA Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barclays</td>
<td>0.617</td>
<td>4</td>
<td>0.850</td>
<td>3</td>
</tr>
<tr>
<td>CBZ</td>
<td>0.974</td>
<td>1</td>
<td>0.990</td>
<td>1</td>
</tr>
<tr>
<td>FBC</td>
<td>0.778</td>
<td>2</td>
<td>0.907</td>
<td>2</td>
</tr>
<tr>
<td>NMB</td>
<td>0.637</td>
<td>3</td>
<td>0.602</td>
<td>3</td>
</tr>
<tr>
<td>ZB</td>
<td>0.512</td>
<td>5</td>
<td>0.532</td>
<td>5</td>
</tr>
</tbody>
</table>

The spearman's rank correlation co-efficient for the mean bank efficiency in Table 4 for each bank over the period 2009-2013 is 0.90 which is significant at five percent level of significant. It is evident that the results of the ranking of the DEA and SFA models are consistent with each other. It can be concluded that
CBZ is the number one bank followed by FBC. This is confirmed by the DEA and SFA mean efficiency estimations in Table 4. Efficiency measures obtained from the SFA model are greater than those obtained from the DEA model (see Table 4, Table 5, Figure 1 and Figure 2). The primary reason for the difference between the DEA and SFA model is due to the presence of measurement error in the efficiency measures from DEA (Sarafidis, 2002). According to Erkoc (2012), part of the difference between the results from DEA and SFA model is due to the imposed function and functional form of the SFA model. The DEA efficiency measures exhibit greater variability than the SFA efficiency estimations.

**Figure 1: Comparison of DEA and SFA Mean Bank efficiency**

**Table 5: Mean average bank efficiency yearwise for the years 2009-2013**

<table>
<thead>
<tr>
<th>Year</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012 Interim</th>
<th>2012</th>
<th>2013 Interim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean DEA Efficiency</td>
<td>0.25</td>
<td>0.462</td>
<td>0.849</td>
<td>0.888</td>
<td>0.901</td>
<td>0.98</td>
</tr>
<tr>
<td>Mean SFA Efficiency</td>
<td>0.310</td>
<td>0.530</td>
<td>0.680</td>
<td>0.880</td>
<td>0.990</td>
<td>0.975</td>
</tr>
</tbody>
</table>

The mean bank efficiencies in Table 5 represent the yearwise bank efficiency scores in the sector for each year between 2009-2013. The efficiency of individual banks in providing services to the market determines the efficiency of the overall banking sector which influences the effectiveness of the domestic financial services. According to Kimani (2007), a banking sector's efficiency can be represented by the average efficiency of its individual banks. The banking sector's efficiency is represented by the yearwise bank efficiency which is the mean bank efficiency for all the banks for each respective year.

**Figure 2: Comparison of DEA and SFA Yearwise Bank Efficiency Scores**
The comparison of the yearwise bank efficiency for DEA and SFA models are shown in Table 5 and Figure 2. It is deduced that yearwise SFA bank efficiency scores are greater than yearwise DEA efficiency scores which is confirmed by studies done by (Sarafidis, 2002 and Erkoc, 2012). Table 5 shows that the yearwise mean efficiency for each year increased on a yearly basis from 2009 to 2013 for both DEA and SFA models. This continuous improvement in yearwise bank efficiency is a result of increased competition amongst the banks who are striving to improve their operational efficiency. Spearman's Rank Correlation Coefficient for the yearwise mean bank efficiencies was measured using SPSS Version 16. The correlation coefficient of 0.943 was found to be significant at five percent level of significant. This means that there is consistency in the values estimated by the two models.

**Stepwise Regression Analysis**

Stock prices were regressed against DEA bank efficiencies, Total Assets, ROE and ROA the following equation (9) was obtained.

\[ Y = 59.367 + 16.273BE - 12.04\log TA, \]

where,
BE is Bank efficiency,
TA is Total Assets,
Y is Stock Prices.

We conclude that the impact of Bank Efficiency on stock prices is higher than the impact of Total Assets. This means that any improvements in Bank Efficiency will lead to improvement in stock prices. This will result in shareholder value creation.

![Normal Probability Plot for DEA](image)

**Figure 3: Normal Probability Plot for DEA**

The Normal Probability plot in Figure 3 is approximately linear, the errors are therefore normally distributed. Figure 3 checks the assumption of normality of error terms. In this case we see that most of the points are clustered around the line which is an indication that the error terms are approximately normal. The assumption of normality is valid. This validates our regression model equation (9). We conclude that bank efficiency is a critical factor in influencing shareholder value creation through increase in stock prices.
Stock prices were regressed SFA bank efficiencies, Total Assets, ROE and ROA the following equation (10) was obtained.

\[ Y = 16.292BE - 1.9939 \]  

where,  
BE is Bank efficiency,  
Y is stock prices.

The model implies that bank efficiency is the variable with the greatest influence on shareholder value creation which is inferred in improved stock prices. We conclude that bank efficiency is a critical factor in influencing shareholder value creation through increase in stock prices.

**Figure 4: Normal Probability Plot for SFA**

The plot in figure 4 is approximately linear, the errors are therefore normally distributed. Figure 4 checks the assumption of normality of error terms. In this case we see that most of the points are clustered around the line which is an indication that the error terms are approximately normal. The assumption of normality is valid. This validates our regression model equation (10). We conclude that bank efficiency is a critical factor in influencing shareholder value creation through increase in stock prices.

**Comparative Analysis of Regression Coefficients**

Stock prices are regressed against DEA and SFA bank efficiency. A comparative analysis of DEA and SFA regression coefficients was carried out. The regression coefficients of equation (7) for both DEA and SFA models and compared in Table 6.
It is noted that both DEA and SFA efficiency scores affect the stock prices significantly at five percent level of significant. The DEA Adj $R^2$ of 0.67 means that 67 percent of the variability in stock prices is caused by the variability in bank efficiency. And for the SFA efficiency scores the Adj $R^2$ is 0.85 meaning 85 percent of the variability in stock prices is caused by bank efficiency.

Stock prices are regressed against DEA and SFA efficiency scores, ROA, ROE and log of Total Assets. The Regression model comparative analysis of the coefficients for both the DEA and SFA is carried out. The regression coefficients are summarized in Table 7.

As can be seen from the Table 7, lnTA, ROE and ROA do not seem to contribute in the explanation of changes in stock prices. These factors do not have a significant influence in the explanation of changes in stock prices. It is noted that DEA and SFA efficiency scores have the greatest influence on stock prices. We conclude that DEA and SFA efficiency scores incorporate more information than lnTA, ROE and ROA.

4. Conclusions and Recommendations

The study sought to enlighten investors and shareholders on how stock prices and bank efficiency are linked to shareholder value creation. The study achieved this by establishing that there is a positive link between stock prices and bank efficiency which leads to shareholder value creation. The study covered a period of five years spanning from 2009 to 2013 and a population of five listed banks on the ZSE. The five banks that were analyzed are Barclays, CBZ, FBC, NMB and ZB. The half-normal distribution approach in STATA Version 12 was employed to estimate parameter $u_i$, which was used to estimate SFA model bank efficiency using equation (6). Lingo Version 10 was employed to solve DEA linear programming equations to determine the bank efficiency scores. SPSS Version 16 was used to regress stock prices against bank efficiency whilst controlling for TA, ROE and ROA.

**Bank Efficiency Estimation and Rankings**

In this study we developed DEA and SFA models to estimate bank efficiency of the five listed banks on the ZSE. The DEA and SFA bank efficiency reflect a comprehensive estimation using multiple inputs and outputs that cannot be taken into account in the traditional financial ratio analysis. The banks were ranked according to their efficiency scores for the period 2009 to 2013. Bank efficiency is regarded as comprehensive evaluation index of achievements. The DEA and SFA mean bank efficiency for each bank was estimated for the period 2009-2013 and then ranked against each other. The ranking for the two models
DEA and SFA were found to be consistent since the spearman's rank correlation coefficient in Table 4 is 0.90 which is significant at five percent. CBZ and FBC were ranked first and second respectively. (see Table 4). Efficiency scores encourage banks to attain a higher level of performance in relation to each other and creating a competitive environment.

The overall banking sector efficiency is represented by the yearwise bank efficiency scores. (see Table 5). Spearman's Rank Correlation Coefficient for the yearwise mean bank efficiencies is 0.943 was found to be significant at five percent level of significant. This means that there is consistency in the values estimated by the two models. The yearwise bank efficiency scores act as a guideline that paves way for future decisions, concerning investment, development, control and supervision. The bank efficiency analysis of the banks listed on the ZSE would benefit management, investors and shareholders.

**Comparative Efficiency Analysis**

The mean bank efficiency for each bank was estimated for the period 2009-2013. Efficiency estimates obtained from the SFA model are greater than those obtained from the DEA model. (See Table 4 and 5). According to Sarafidis (2002), the primary reason for the difference between the DEA and SFA efficiency scores is due to the presence of measurement error in the efficiency measures from DEA. Studies by Erkoc (2012), show that part of the difference between the results from DEA and SFA models is due to the imposed function and functional form of the SFA model in this study.

The Spearman rank correlation coefficient for the results between SFA and DEA model for Table 4 and 5 are 0.900 and 0.943. These correlation coefficients show a strong correlation between the results from the DEA and SFA models indicating that the results are consistent. We conclude that it is impossible to suggest one approach as all approaches have positive and negative features and can be used jointly as they provide complementary information (Erkoc 2012).

**Stock Prices and Bank Efficiency**

In this study we estimated efficiency of banks listed on the ZSE over a period of 2009 to 2013. By using DEA and SFA models under profit oriented approach we estimated bank efficiency scores. The link between stock prices and bank efficiency whilst controlling for TA, ROE and ROA was analyzed using stepwise regression analysis in a statistical software package SPSS Version 16. According to the analysis carried out using SPSS Version 16 it was concluded that there is a positive significant relationship between stock prices and bank efficiency for both DEA and SFA models which leads to shareholder value creation. Shareholder value creation is based on the stock prices and assumes that the share price reflects the market’s expectations about the firm's future value creation performance. Any improvements in the bank efficiency will result in improvements in stock prices.

In this study we conclude that bank efficiency is a variable that significantly affects shareholder's value which is inferred through changes in stock prices. This is in line with several other studies in other countries which found a positive association between stock prices and bank efficiency (Pasiouras et al., 2008).The results seem to support the argument that stock prices respond positively towards improvement in bank efficiency.

**Research Conclusions**

In this study DEA and SFA models are multiple input and output techniques used to estimate bank efficiency scores and their rankings. The results of both models were found to be consistent. The difference between DEA and SFA efficiency scores is due to the presence of measurement error in DEA model and due to the imposed function and functional form of the SFA model. DEA and SFA models are useful tools for benchmarking DMUs. They can help managers to identify and remedy under performance, and regulators (RBZ) to encourage efficiency and ensure that investors and shareholders benefit from the resulting efficiency gains.
The stock prices were regressed against mean bank efficiency whilst controlling for TA, ROE and ROE. The study shows that there is a positive link between bank efficiency of listed banks on the ZSE and their stock prices, which will result in shareholder value creation.

According to Kasman and Kasman (2011), stocks of profit efficient banks tend to outperform their inefficient counterparts and that managerially efficient banks should generate more profits and greater shareholder value. According to Guzman and Reverte (2008), it means that banks with higher efficiency have higher shareholder value. The findings of this study are in line with the findings of Pasiouras et al., (2008), who studied Greek listed banks and Beccalli et al., (2006), who studied European banks. The results show that bank efficiency has the greatest influence on stock prices as compared to the traditional accounting measures of performance. We conclude that improvements in bank efficiency will result in improvements in shareholder value creation through increase in stock prices.

**Research Recommendation**

Future researchers, policymakers, investors, bankers are encouraged to rank and estimate bank efficiency of a set of firms active on the ZSE by employing the DEA and SFA models. Efficiency scores encourage banks to attain a higher level of performance in relation to each other and creating a competitive environment. Bank efficiency data of listed banks, have implications for the banking sector to improve operational efficiency. The efficiency of individual banks in providing services to the market determines the efficiency of the overall banking sector which influences the effectiveness of the domestic financial services. Bank efficiency scores act as a guideline that paves way for future decisions, concerning investment, development, control and supervision. DEA and SFA models are useful tools for benchmarking DMUs. They can help managers to identify and remedy under performace, and regulators (RBZ) to encourage efficiency and ensure that investors and shareholders benefit from the resulting efficiency gains. It is recommended that another research be carried out in other sectors (mining, agriculture, industrials, tourism, and telecommunications).

**References**


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