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Determinants of Banking Sector Efficiency in Kenya: Application of Non-parametric Data Envelopment Analysis (DEA) Model

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The financial system plays an important role in the economic development and financial stability of a country. Banks play a critical role in facilitating stability of the financial system and economic development. Evaluating the determinants of banking efficiency therefore provides insight to establish the target factors that influence efficiency to facilitate inefficiency identification and elimination.

The study's objective was to evaluate the determinants of banking sector efficiency in Kenya for the period 2006 to 2017. Secondary data were collected from the annual reports and financial statements of 10 commercial banks listed on the Nairobi Securities Exchange (NSE). The analysis was carried out in two stages. In the first stage, the non-parametric Data Envelopment Analysis (DEA) approach was used to compute the efficiency scores. In the second stage, panel regression

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analysis was then performed to evaluate the determinants of efficiency. The results showed that Capital Adequacy and Market Capitalization are significant in determining the Efficiency of a bank, p =0.0315< 0.05 and p=0.0253< 0.05 respectively. Further, bank size (p = 0.000< 0.05), capital adequacy (p = 0.0014< 0.05), leverage (p = 0.0000< 0.05) and Liquidity risk (p = 0.0000< 0.05) have a significant effect on Scale Efficiency. Market capitalization (p = 0.5056>0.05) is statistically insignificant in influencing the Scale Efficiency of the bank. From the findings, the study, therefore, concludes that, bank size, capital adequacy, liquidity risk, leverage and market capitalization have a significant effect on bank efficiency. The study recommends that bank managers should focus on improving management quality by ensuring compliance with prudential guidelines issued by the Central Bank of Kenya. Particularly, bank managers should ensure capital adequacy and market capitalization requirements are met since they are found to be the key drivers of efficiency and performance. Further, maintaining an optimal bank size, market capitalization, appropriate liquidity risk and leverage level is significant in guaranteeing improved performance.

Keywords: Banking; efficiency; liquidity risk; capitalization.

1. INTRODUCTION

Efficiency is the ability to generate output from a given level of input. More output per unit of input reflects relatively greater efficiency. If the greatest possible output per unit of input is achieved, a state of absolute or optimum efficiency has been achieved and, it is not possible to become more efficient without new technology or other changes in the production process [1]. Therefore, efficiency refers to the maximizing of outputs in such a way that the input resources are less utilized. Banking efficiency, from the par view of the wider concept, can be defined as the difference between observed quality of input and output variables with respect to the optimal quality of input and output variables.

Globalization, deregulation, mergers & acquisitions, privatization of state-owned banks and the emergence of technological innovations such as mobile phone banking and internet or online banking have led to a significant transformation of the banking sector in Kenya. Today, many banks have developed mobile banking applications and adopted online banking to diversify their income streams while improving the efficiency of services.

The customer of today has become increasingly aware of their rights with respect to service offering, thus expecting efficient, seamless and uninterruptible services. Therefore, in an effort to meet the constantly changing customer needs and preferences, banks have had to become innovative in their service and product offerings.

Hasan et al. [2], indicate that an efficient bank is capable of obtaining maximum output from a given level of input or minimizing inputs to achieve a given level of output. The inputs; deposits, borrowings, labour, and fixed assets are utilized in the operations of the bank to generate outputs; net interest income, non-interest income, credit and investments. Generally, deposits are dominant in producing all outputs from the banking operations through credit creation.

However, the efficiency of production is varied across the banks due to their unique operating environments. Thus, for improved economic performance to be achieved, bank competition and efficiency are vital components. Economic and financial development heavily relies on an efficient and fully functioning financial system because banks participate through the financing of investments that contribute to economic development. Saleh, [3] argues that bank managers should increase the efficiency in using tangibles assets to generate income. This is a great test of the managerial acumen of bank managers as it enables determine how well the assets of the bank are being utilized.

Pranowo and Manurung [4] posit that, a firm's efficiency measures how productively the firm is using its assets; the principal revenue-generating resource of the business to generate revenues. Fethi and Pasiouras [5] argued that the performance of the banking system is important not only to its managers, but also to customers, investors, regulators, and the society at large. This view was further advanced by Staub et al. [6] who provided that the development of the banking system and the increase in its efficiency are related to greater economic growth. Banking institutions with low levels of efficiency could therefore become insolvent, causing losses to

depositors and thus threatening the stability of the financial system. Therefore, due to the importance of the banking system in the economy, scholarship on bank efficiency contributes to a better understanding of the determinants of bank efficiency, analysis of the effects of new rules on bank efficiency, identify good and bad management practices, and to support decisions in public policy. Staub et al. [6] indicate that changes in average banking sector efficiency over time could indicate that such efficiency is influenced by changes in bank-specific and macroeconomic factors and regulatory environment. Both macroeconomic and bank-specific factors are critically important in determining bank efficiency.

Studies on determinants of bank efficiency have considered both macro-economic and bank specific factors. This study, however, dwelt on the bank-specific factors; bank size, capital adequacy, market capitalization, liquidity risk and leverage. Other studies such as Vu and Nahm, [7], used equity over total assets, return on assets or equity, loans-to-total assets, type of ownership, and bank configuration among others to evaluate the determinants of efficiency.

1.1 Objectives and Hypotheses

1.1.1 General objective

The main objective of the study was to evaluate the determinants of the efficiency of commercial banks listed on the Nairobi Securities Exchange in Kenya.

1.2 Specific Objectives

1. To evaluate the effect of market capitalization on banking efficiency
2. To examine the effect of liquidity risk on banking efficiency
3. To investigate the effect of capital adequacy on banking efficiency
4. To assess the effect of bank size on the efficiency of commercial banks

1.3 Hypotheses

The following hypotheses were therefore developed:

1. **H_{01}:** There is no significant relationship between market capitalization and bank efficiency in Kenya
2. **H_{01}:** There is no significant relationship between liquidity risk bank efficiency in Kenya
3. **H_{01}:** There is no significant relationship between capital adequacy and bank efficiency in Kenya
4. **H_{01}:** There is no significant relationship bank size and bank efficiency in Kenya

1.4 Conceptual Framework

The following conceptual framework is adopted for this study.

2. LITERATURE AND EMPIRICAL REVIEW

Extant literature shows that no unanimity exists on the determinants of bank efficiency. For instance, Williams and Nguyen [8], Rezitis [9], and Vu and Nahm [7], found a positive relationship between bank size and efficiency. Contrastingly, Chen et al. [10] and Akin et al. [11] revealed a negative effect of bank size on efficiency. Further, Altunbas et al. [12],

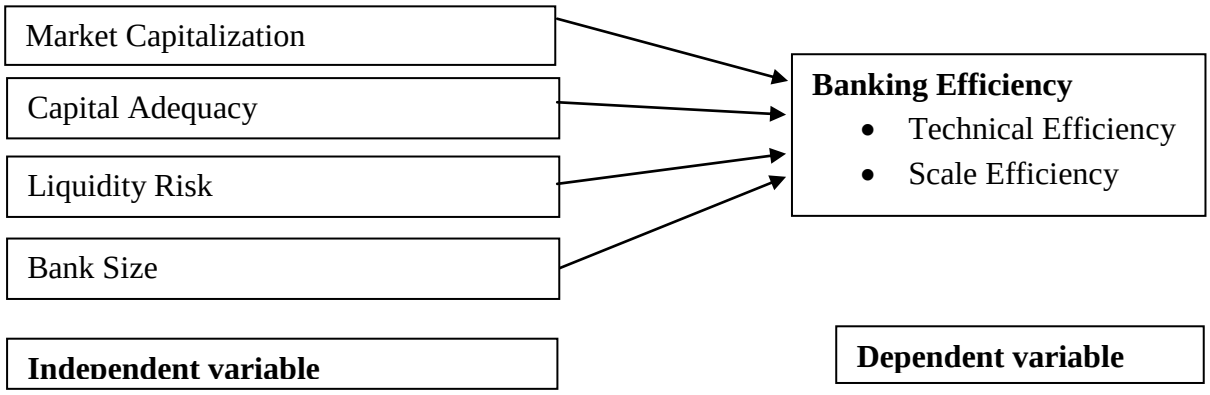

Fig. 1. Conceptual framework

Chortareas et al. [13], and Vu and Nahm [7] found a positive relationship between the level of capitalisation and bank efficiency, while Pasiouras et al. [14] established that the level of capitalisation had a negative impact on efficiency. Similarly, Ariff and Can [15] and Sanchez et al. [16] found that banks with higher ROE were more efficient. Similarly, Sufian and Noor [17] showed that a positive relationship exists between bank efficiency and loan intensity, bank size, capitalization, and profitability. The results further indicated that banks that are technically more efficient are those with a smaller market share and low non-performing loan portfolios.

The branch network is associated with an increase in bank size reflected in the banks' total assets. As such, bank size is used to determine whether the bank enjoys economies of scale. Pavkovic et al. [18] indicate that an increase in bank size can generate an increase in efficiency level. Stewart et al. [19] argued that banks with large branch networks and those that have been in existence for a long time present low-efficiency levels. According to the economies of scale theory, when a firm grows in size, its operating cost per unit will decrease due to the achievement of lower production cost per unit as the production cost is spread over a larger volume of output. Sapci and Miles, [20] however, found that an increase in asset size improves bank efficiency initially, and that, after reaching a certain optimum point, the increase may actually lead to lower bank efficiency implying that the relationship between bank size and efficiency is not always positive.

Garza-García, [21] in a study of 332 Mexican banks on determinants of bank efficiency, the results showed that net interest margin and non-performing loans reduce bank efficiency. The findings further indicate that, large and very large banks are more efficient than small and medium-sized banks. Small banks were also found to be the least efficient with non-state-owned commercial banks being more efficient than state-owned commercial banks. Similarly, Partovi and Matousek [22] and Tan & Floros [23] argued that the costs associated with managing non-performing loans including legal costs, employee expenses related to the administration, monitoring and collection of non-performing loans, costs of taking over, maintenance and disposal of the collateral against the non-performing loans among other costs, reduces the bank's operational efficiency. Consequently, the bank's capital will be affected in which case the concerned bank will be required to make provision to cover such risks, thus limiting its ability to generate interest income.

Rose and Hudgins [24], intimate that capital is a key determinant of bank efficiency as it acts as a buffer against the risk of financial and operational losses and provides resources for the expansion and development of new products and services. Well-capitalized banks also provide increased public confidence and assurance to depositors and creditors of the financial stability of the bank. Sufficient capital enables the bank to increase lending without necessarily worrying about the inability to assume the risk of losses occasioned by potential non-performing loans and other operational risks. Capital facilitates credit creation and increase in interest income and lowers the cost of credit. The amount of capital is therefore expected to improve the efficiency of the bank Karim et al. [25]. Repkova [26], found that the level of capitalization, liquidity and portfolio risk have a positive relationship with bank efficiency.

3. METHODOLOGY

3.1 Data Collection

The study used secondary data collected from the annual reports and financial statements for the period 2006 to 2017. It involved data for 10 commercial banks listed on the Nairobi Securities Exchange. The eleven-year period selected for the study was important to establish the changes in performance and efficiency of commercial banking operations over time. The period also captures the times when the country underwent major political events which may have affected banking operations and their profitability. The period also captures the various prudential guidelines and banking regulations given by the central bank of Kenya.

3.2 Data Processing and Analysis

The data was collected and analyzed in two stages. The first stage involved the computation of the efficiency scores using the DEA model. The second stage involved panel regression analysis to estimate the determinants of efficiency.

3.3 Data Envelopment Analysis (DEA) Model Specification

This model was first proposed by Charnes et al. [27] and has been applied to measuring the efficiency of public firms such as schools and hospitals. The DEA methodology has been applied to analyze the relative efficiency of commercial banks [28,29]. According to Fethi and Pasiouras [5], out of 196 studies that they reviewed, about 77 percent of them used the DEA model in measuring the efficiency and productivity growth of commercial banks. Rao and Lakew [30], also applied the DEA methodology while assessing the cost efficiency of Ethiopian Banks. The method measures the relative efficiency of firms and does not require a particular functional form to estimate the efficiency of a decision-making unit like is the case with other parametric approaches [16].

There are two most commonly used DEA models; the CCR model, and the BCC model. The CCR model works best under the constant return to scale (CRS) hypothesis, which provides the decision-making units (DMUs) are operating at an optimal scale [27]. This assumption is however not realistic since factors such as imperfect competition and constraints in the financing may not allow a bank to operate at an optimal scale. On the other hand, the BCC model, under the variable return to scale hypothesis, contends that not all decision-making units (banks) are operating at an optimal scale [31]. The model essentially begins with the CCR model and presumes that the DMUs that are being evaluated may be operating under variable return to scale. This denotes that, in applying the BCC model the relative efficiency of each decision-making unit (DMU) is found by comparing it with those efficient DMUs that are operating at a similar capacity.

Now, since the BCC model accounts for the variability in the scope of operation that may exist among the banks, the BCC model is preferred compared to the CCR model. This is because it will assist to capture all the variability in the efficiency levels at different times. Further, the application of the DEA model provides two alternatives for measuring the efficiency of commercial banks. These two alternative models are the input-oriented model and the output-oriented model.

The input-oriented model is used if we wish to examine a firm's ability to minimize the number of inputs used for a given level of output, with the level of output remaining constant. On the other hand, the output-oriented model is used if we wish to examine the ability of a firm to maximize its output using a given level of input, with the level of input remaining constant. Therefore, the choice of the model is subjective and depends on the level of managerial inclination to cost reduction or revenue maximization. Where managers have more control over the inputs, (cost), the input-oriented model is appropriate for measuring the efficiency of a firm and vice versa. Generally, bank managers have the tendency to control inputs (costs) and the output is uncertain, therefore the input model will be more appropriate for this study.

3.4 DEA Model Specification

From the above discussion, the mathematical expressions can then be simplified to be able to run on a linear programming package as follows:

$$Maximize, \theta = \sum_{r=1}^{s} u_r y_{r0} \tag{1}$$

$$Subject, to$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0,\ j = 1, ..., n \tag{1.1}$$

$$\sum_{i=1}^{m} v_i x_{i0} = 1$$

$$Nonnegativity$$

$$u_r, v_i \geq 0 \tag{1.2}$$

Where the emphasis is on reducing inputs rather than maximizing outputs by the decision-making unit, the model is specified as follows:

$$Minimize, \theta$$

$$Subject, to \tag{2}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0}, ..., i = 1, 2, 3, ..., s;$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{i0}, ..., r = 1, 2, 3, ..., m;$$

$$\lambda_j \geq 0, ...,\ j = 1, 2, 3, ..., n.$$

This approach is popular with many managers. In the banking sector, the emphasis is usually on minimizing costs as much as possible. The result is to achieve greater performance and profitability. The validity of this view is the fact

that outputs are more often uncertain and cannot be determined with accuracy in advance and therefore difficult to control.

3.5 Selection of Inputs and Outputs

After a review of the literature on many studies on commercial bank efficiency, the selection of inputs and outputs to use is a subjective exercise. Baking efficiency can be studied from two main perspectives; the production approach and the intermediation approach. The production approach addresses physical inputs, such as capital and labor. This approach looks at banks as firms producing different deposits and loan accounts. Banks deal with transactions, and documentation and provide custodial services for their customers who own these accounts. Therefore, the number of accounts (Account opening section) and transactions (Number of transactions processed) are regarded as bank outputs. According to Ferrier and Lovell [32], the number of deposits and loan accounts is usually used as the measure of bank output rather than the details in transactions and documents.

On the other hand, the intermediation approach looks at banks as financial intermediaries. The banks provide a link between surplus income units (depositors) and deficit income units (borrowers) in the economy. In this connection, the value of bank loans and investments is thought of as output, while labor, deposits, and capital are treated as inputs. This approach is distinguished from the production approach by adding deposits as an input, leading to consideration of both operating and interest [33]; Fries and Taci, [34].

From the above literature, it follows that the intermediation approach has been used by many authors due to its practicality. This approach will therefore be followed for this study. Different combinations of input and output; such as Deposit, interest expenses, operating expenses, loans, investments, interest income, and noninterest income will be used. The first three are inputs while the last four are outputs [35] and Singh, [36]. The input-oriented DEA model is important to analyse the efficiency of commercial banks under both Constant Return to Scale (CRS) and Variable Return to Scale (VRS) assumptions. The technical efficiency and pure technical efficiency scores are then obtained which are used to compute Scale efficiency by dividing technical efficiency by pure technical efficiency. The DEA approach requires that the inputs and outputs for the decision-making units are carefully selected. Following previous studies, the current study identifies the inputs as operating expenses, total deposits and interest expenses while outputs are interest income, total loans and other income.

3.6 Econometric Model Specification

The truncated Tobit regression model was applied to evaluate the determinants of bank efficiency as the efficiency values are restricted between 0 and 1, and therefore the use of the ordinary least squares or the generalized regression models would be misleading.

The general regression equation is specified as follows:

$$(Eff_{it}) = \beta_{io} + \beta_{i1}X_{i1} + \beta_{i2}X_{i2} + \beta_{i3}X_{i3} + \beta_{i4}X_{i4} + \beta_{i5}X_{i5} + \varepsilon_{it} \quad (3)$$

Where: Eff. Represents Bank Efficiency, X_{i1}, Bank Size, X_{i2}, Capital Adequacy, $X_{i3,}$ Liquidity Risk, $X_{i4,}$ Market Capitalization and X_{i5} is the leverage. β_{i0} is the constant and β_{i1} – β_{i5} are coefficients and $\boldsymbol{\varepsilon}$ is the error term, i represents the banks identifier, t is the time dimension of the data.

The efficiency is measured under two assumptions; variable returns to scale (VRS) and Constant returns to scale (CRS). The CRS assumption in the CCR model restricts its application to efficiency studies and is suitable only when all firms are operating at an optimal scale, hence easily comparable in terms of their operations [37]. However, in a market-driven economy where competition, price differences, and constraints with resources are present, all firms may not be operating at optimal scale. Hence, Banker et al. [31], proposed the BCC DEA model for the firms operating under variable returns to scale (VRS) assumption. Under the CCR model, the technical efficiency calculated is comprised of both technical efficiency and scale efficiency. However, the BCC model decomposes the technical efficiency obtained from the CCR model into technical efficiency and scale efficiency by relaxing the CRS assumption in the model. The BCC model can be applied to multiple inputs and multiple outputs [37]. The Tobit regression model was used in this study because efficiency values, which are the independent variables, are restricted to between 0 and 1, and therefore the use of the ordinary

least squares(OLS) or generalized regression models (GMM) would be misleading.

4. RESULTS AND DISCUSSION

The results in Table 1 under the VRS assumption indicate that only Capital Adequacy and Market Capitalization are significant in determining the Technical Efficiency of a bank. The result is supported by the p = 0.0315<0.05 and p = 0.0253<0.05 respectively. This means that a unit change in Capital Adequacy would result in a reduction in efficiency by 0.0127, while market capitalization would lead to an increase in efficiency by 0.0403. Further, the results show that bank size (p = 0.2526>0.05), liquidity risk (p = 0.7729>0.05) and financial leverage (p = 0.0637>0.05) are insignificant, and hence have no influence on bank efficiency.

Similarly, Table 2 shows the output on the determinants of efficiency under the CRS assumption. The results indicate that, all the bank-specific variables; bank size (p = 0.0000<0.05), capital adequacy (p = 0.0000<0.05), liquidity risk (p = 0.0000<0.05), leverage (p = 0.0000), and market capitalization (p = 0.0145<0.05) are significant in influencing the efficiency of a bank.

Table 3 shows the output of the determinants of Scale Efficiency (SE) of the banking sector. The results indicate that all bank-specific variables; bank size (p = 0.000), capital adequacy (p = 0.0014), leverage (p = 0.0000), and Liquidity risk (p = 0.0000) are significant in influencing bank efficiency. However, the results show that market capitalization (p = 0.5056) is insignificant in influencing the SE of the banking sector.

From this finding, there is a strong indication that the independent variables tested, have a strong influence on bank efficiency in Kenya, ceteris Paribas. The results, therefore, lead to the conclusion that bank size, capital adequacy, liquidity risk, leverage, and market Capitalization have a significant effect on bank efficiency.

Table 1. Determinants of efficiency –Variable Returns to Scale (VRS)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.626430	0.547664	-1.143822	0.2527
Bank Size	0.021108	0.018452	1.143937	0.2526
Capital Adequacy	-0.012650	0.005881	-2.151133	0.0315
Liquidity Risk	0.000446	0.001546	0.288519	0.7729
Leverage	0.006928	0.003736	1.854305	0.0637
Market Capitalization	0.040274	0.018010	2.236213	0.0253

Table 2. Determinants of efficiency –Constant Returns to Scale (CRS)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.508978	0.619970	2.433952	0.0149
Bank Size	-0.106049	0.020888	-5.076916	0.0000
Capital Adequacy	-0.027748	0.006657	-4.168024	0.0000
Liquidity Risk	0.013107	0.001750	7.489308	0.0000
Leverage	0.025444	0.004230	6.015611	0.0000
Market Capitalization	0.049820	0.020388	2.443639	0.0145

Table 3. Determinants of bank efficiency – Scale Efficiency (SE)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	3.129009	0.442129	7.077139	0.0000
Bank Size	-0.127081	0.014897	-8.530905	0.0000
Capital Adequacy	-0.015141	0.004748	-3.189221	0.0014
Liquidity Risk	0.012668	0.001248	10.15068	0.0000
Leverage	0.018561	0.003016	6.153373	0.0000
Market Capitalization	0.009679	0.014539	0.665681	0.5056

The findings are consistent with Banna et al. [38] who, on examining the effect of the global financial crisis and other factors on the efficiency of Bangladesh commercial banks, using the Data Envelopment Analysis (DEA), found that financial crisis, bank size, capital adequacy ratio, average return on equity and real interest rate had a significant effect on bank efficiency in Bangladesh.

Similarly, the finding on capital adequacy, as a determinant of bank efficiency is consistent with Yener et al. [39] who found a negative relationship between capital adequacy and bank operating efficiency. The findings are further supported by Delis & Papanikolaou [40] and Tecles & Tabak [41] who found a positive relationship between capitalization and bank efficiency. From these findings, it can be observed that adequately capitalized banks are able to utilize available investment opportunities as and when they arise while at the same time mitigating the risks associated with operations. The banking sector in Kenya could therefore be argued to have a preference to more capital-holding behaviour with a low-risk appetite.

Further, the findings are consistent with Muazaroh et al. [42], who found that capital adequacy has a positive and significant effect on efficiency. The findings are also supported by Gwahula, [43] who found that bank efficiency is influenced by both bank-specific, industry-specific and macroeconomic factors. He showed that, bank size, profitability measured by NIM, liquidity, as well as capital adequacy had a significant effect on bank efficiency in Tanzania. The study also indicated that industry-specific and macroeconomic factors; market share and market concentration and GDP had a significant influence on bank efficiency while Nonperforming loans (NPL), ownership and Consumer Price Index (CPI) were insignificant. The findings are also supported by Odunga et al. [44] who showed that liquidity increases with operating efficiency. To this end, banks maintain high liquidity so as to meet demand deposits by customers and avoid the possibility of bank runs. The efficiency of the bank is therefore improved. Similarly, the results are supported by David and Wilson [45] who reported a positive and significant relationship between bank efficiency and bank size. This finding, on the relationship between bank size and efficiency is further reinforced by Hughes et al. [46]. They argued that, due to their ability to access and mobilize resources, both human and material, large banks by size, are expected to be more efficient relative to small banks. The access and ability to mobilize resources enable big banks to improve on their efficiency level by leveraging on economies of scale.

5. CONCLUSION

The paper investigated the operational efficiency and performance of the banking sector in Kenya with a specific focus on the banks listed on the Nairobi Securities Exchange. Data Envelopment Analysis (DEA) approach was used. The findings showed that the CCR-I constant returns to scale assume the presence of the same change of outputs in case of a proportional change of inputs. The BCC-I variable return to scale model on the other hand contends that there are variable or increasing or decreasing returns to scale of the inputs and outputs of each DMU. Increasing returns to scale occurs where the input increases at a certain portion and the outputs increase more than proportionate to that of inputs and vice versa. From this argument it follows that the BCC-I VRS model captures the real business environment conditions which are in a constant state of flux; inflation, competition, and technology among others in measuring efficiency.

The individual efficiency scores for each year for all the banks were estimated over the period from 2000 to 2015. This period takes into account the global financial crisis of 2007 to 2009, and also the political events that took place in the country in 2007/2008. The study helps in capturing the impact of the two major events on the operations of the banking sector in Kenya. Under both the constant returns to scale (CRS) and variable returns to scale (VRS) approaches the banking sector as represented by the listed banks was observed to be efficient.

The global financial crisis and the political events in the country during the highlighted period did not affect the efficiency of the banking sector in Kenya. Under the BCC model, the banks were DEA-efficient prior to the global financial crisis and the political events in the country. Therefore, the strong efficiency level supported the sector which contributed to the resilience demonstrated during the political upheaval and global financial crisis.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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