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RESEARCH ARTICLE

Technical Efficiency for Strategic Change and Global Competitiveness[1]

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Banks need to improve their technical efficiency to succeed in the long run.

Private banks show a general increase in scale efficiency.

Technical efficiency varies from bank to bank.

Technical efficiency helps the banks in developing countries to be competitive in this era of globalization.

It is known that financial institutions, particularly commercial banks, play a crucial role in the economy of all developing nations (King and Levine, 1993; Levine and Renelt, 1992). Globalization has resulted in integration of the economy and markets with the rest of the world (Paul, 2015). The banking sector has undergone drastic structural changes in the form of privatization and globalization in recent years in most developing countries, with the intention of increasing efficiency levels and competitiveness, despite the diverse views on its implications (Suresh and Paul, 2010). Mere transfer of ownership from public to private hands is unlikely to improve performance. Significant organizational changes in systems, structures, and cultures are essential for realizing desirable performance outcomes following privatization (Ramaswamy and Von Glinow, 2000).

Service quality is important for the survival of any bank in an era of cut-throat competition, as consumers value efficiency and quality in retail banking (Paul *et al*., 2015). Commercial banks have undergone tremendous technological and managerial changes (including computerization) to catch up with the pace of globalization and new business environments across the globe. They have to achieve international benchmarks with best practices. As one of the fast-growing, developing economies in the African region, Kenya has captured the attention of the rest of the world in recent years. The banking sector in Kenya has been facing serious problems during the past few decades. Though the financial system in Kenya has the advantage of operating in a closed and regulated environment, it

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went through an absolute overhaul during the 1990s. The Central Bank of Kenya (CBK) has initiated many reforms, such as deregulation, use of technology, delicensing, etc. The CBK has also created five public-sector banks on a national basis (national banks) with a network spread throughout the country (Central Bank of Kenya – Bank Supervision Annual Report, 1995, 2014). Foreign banks operating in Kenya were subject to the same requirements as applicable to domestic banks. These reforms created competition and immense pressure in the banking industry, and triggered greater use of information technology, credit, transparent balance sheets, and product diversification. The recent development in mobile phone technology has reached a large number of consumers in Kenya, who were otherwise excluded from formal access to a range of financial services (i.e., mobile money, mobile savings, mobile insurance, and mobile credit) at an affordable price (Wijesiri and Meoli, 2015).

Technical efficiency is the effectiveness with which a given set of inputs is used to produce an output. It comprises pure technical efficiency and scale efficiency. The scale efficiency is the minimum amount of variable return to scale, or constant return to scale, required in a given production (www.investopedia.com). The efficiency of the Kenyan banking system has been a subject of concern, mainly due to problems such as high interest rate spread, increase in non-performing assets, etc. In this competitive business environment, the commercial banks are under pressure to make credit more affordable and expand their lending portfolio, to reverse the slowdown and spur growth. Therefore, an analysis of banks' efficiency is important from the point of view of consumers, the market, the government, and society at large. Private banks in Kenya perform well, with better liquidity assets, compared to public banks and foreign banks. Miencha and Selvam (2011) have discovered that commercial banks in developing countries such as Kenya still have a long way to go in order to survive in an era of globalization.

Based on the points mentioned above, we seek to measure, compare, and highlight the technical efficiency of banks in Kenya, with the goal of benchmarking to global standards, keeping in mind that these tools would help as catalysts for change. Following the calls to develop a better understanding of competitive advantage (Clougherty and Moliterno, 2010; Coff, 1999), we focus our empirical attention on strategic concepts such as technical efficiency and scale efficiency in this study.

Statement of the problem and objectives of the study

In the financial services sector, an attempt to study the efficiency of banks is important for benchmarking and strategic planning, which in turn result in better consumer services. In this context, it is worth noting that the banking industry in most developing countries — including Kenya — used to be dominated by public-sector banks. However, the business environment has changed due to the use of technology and the introduction of professional management by private and foreign-sector banks that gained remarkable attention in the banking industry. The private-sector banks, on a par with their counterparts in the public sector, play an important role in the development of the Kenyan economy. Therefore, we compute and compare the efficiency scores of private as well as public-sector banks in Kenya. Many firms in the service industry, including the banks, face a problem of not producing better results in terms of efficiency. In particular, the last decade witnessed continuous changes in regulation, technology upgrading, and competition in the global financial services industry all over the world; the Kenyan commercial banks are no exception to this. The efficiency of banks in general, and technical efficiency in particular, has become an important issue in Kenya (Central Bank of Kenya – Bank Supervision Annual Report, 2011). It is therefore crucial to benchmark the efficiency of banks operating in Kenya based on efficiency, as focused on in this study.

Recognizing the importance of efficiency and quality is the first step to offer better services for consumers in

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this era of globalization. The objective of the present study is to measure and analyze the technical efficiency scores of commercial banks in Kenya by using a non-parametric technique — data envelopment analysis (DEA). For instance, technical efficiency can be measured as the ratio between the observed output and the maximum output, under the assumption of fixed input, or, alternatively, as the ratio between the observed input and the minimum input, under the assumption of fixed output (Debreu, 1951).

Literature review

Researchers have made efforts to analyze efficiency and productivity levels with the help of different tools, such as DEA. Kox and Leeuwen (2013) use a DEA method to construct the productivity frontier by subsector for business services in 13 European Union countries. Between 1999 and 2005, they observed a persistence of scale diseconomies, with scale efficiency falling rather than growing over time. Their results show that economic reform with market openness may have positive productivity effects. Sahoo and Nauriyal (2014) discuss the trends and determinants of technical efficiency of software companies in India during 1999–2008 by applying an input-oriented DEA model, and the results demonstrate that the mean technical efficiency of the software industry in India is low.

Similarly, a number of researches have been conducted on the banking sector in a global context. Some of these have worked on banking efficiency measurement. Paul and Kourouche (2008) evaluated 10 Australian banks on their technical efficiencies and found that the extent of technical efficiency varied across the banks and over the years. Debnath and Shankar (2008) used the Banker, Charnes, and Cooper (BCC) (Banker *et al.*, 1984) and Charnes, Cooper, and Rhodes (CCR) (Charnes *et al.*, 1978) models on over 50 Indian banks with two inputs (total assets and deposits) and six outputs [operating profit, interest income, profit after tax (PAT), advances, net non-performing assets (NPAs), and total income] to examine and compare the efficiency of banks in India. They identified the priority areas for banks, which could improve their efficiency. Rajput and Gupta (2011) carried out a similar study and found that the efficiency of the Indian banking sector was above 80%. In a related study, Arbussà and Bernal (2003) found that the development of new platforms such as online banking has the potential to intensify the competition level in the banking industry in countries like Spain. They analyzed the strategic implications of deployment of online technology on existing and new players. Koutsomanoli-Filippaki *et al.* (2009) employed the stochastic frontier methodology to investigate the impact of structural reforms on profit efficiency in the banking industry of four new European Union member countries over the period 1999–2003. Their findings suggest that reforms in the banking market are of critical importance for profitability, as they assert a positive impact on profit efficiency. Researchers have studied the competition and efficiency levels in the banking sector in South Africa and Ghana, and shown that although the average technical efficiency in the banking sector was trending upward over the period, the number of efficient banks was falling (Biekpe, 2011; Mlambo and Ncube, 2011) due to monopolistic competition. Mwega (2011) reviewed the broad structural shifts in banks and other financial institutions in Kenya in the face of globalization and found that Kenya has moved into universal banking. He also reported that small banks are the least competitive in Kenya. Omran (2007) examined the financial and operating performance of 12 Egyptian banks from 1996 to 1999 after privatization and found strong evidence to support the theory and previous empirical findings that banks with greater private ownership perform better. Similarly, Okeahalam (2008) compared the impact of internationalization on the performance of banks in Namibia and Tanzania. He found that in Namibia, all of the foreign banks were larger but more inefficient than the domestically owned banks. In Tanzania, foreign banks were more efficient than domestic banks.

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The summarized results of the literature review are given in **Table 1**, with a focus on the efficiency of banks using DEA models [CCR and BCC inputs and outputs in various decision-making units (DMUs)]. The present study is unique because, unlike others, we emphasize the effect of scale efficiency using BCC and CCR efficiency scores.

Based on the literature review, the present study tests the following null hypothesis:

NH: There is no significant difference in the efficiency level of private and public-sector banks in Kenya.

Method

Sample selection

As of March 31, 2012, there were 45 banks — 5 public-sector banks, 28 private-sector banks, and 12 foreign banks — in Kenya (Central Bank of Kenya – Bank Supervision Annual Report, 2013). The required data for the purpose of this study was available only for 20 banks, including 2 public-sector banks (namely National Bank of Kenya, Development Bank of Kenya) and 18 private-sector banks (namely Equity Bank of Kenya Ltd, Commercial Bank of Africa, Family Bank of Kenya, Jamii Bora Bank of Kenya, Cooperative Bank of Kenya, Equatorial Bank of Kenya, Diamond Trust Bank of Kenya, Fidelity Commercial Bank, Giro Commercial Bank, Oriental Commercial Bank, Trans National Bank of Kenya, United Bank of Africa, Victoria Commercial Bank, CFC Bank of Kenya, Kenya Commercial Bank, Chase Bank, and Credit Bank of Kenya). So, the sample size is 20 banks.

Sources of data

The study was based on secondary data published by the CBK and the websites of the respective banks. Besides, the required data was collected from the relevant annual reports of banks. The present study covers a period of four financial years (2009/10 to 2012/13) and the analysis was carried out using time-series data relative to the individual year frontiers (annual data) for four years.

The tool used for analysis — DEA

DEA is a non-parametric method for the measurement of efficiency relative to various DMUs (Debnath and Shankar, 2008). DMUs are the homogeneous units and in the present study, DMUs are the sample commercial banks. The technical efficiency score is the total weighted sum of outputs divided by the total weighted sum of inputs. In this model, efficiency was measured by the ratio of weighted outputs to weighted inputs. The efficiency of a bank can be measured in terms of how resourcefully a bank utilizes its inputs by using the following formula:

$$\max h_0(u,v) = \frac{\sum_{r=1}^{s} v_r y_{r0}}{\sum_{i=1}^{m} u_i x_{i0}}$$

where

x_{ij} = the amount of input i utilized by the jth DMU
y_{rj} = the amount of output r utilized by the jth DMU
u_i = the weight given to input i.

Following prior studies (Debnath and Shankar, 2008; Paul and Karouche, 2008; Rajput and Gupta, 2011), we selected the input and output in our model. The inputs used in this study for DEA are interest expenses, labor-related expenses, total deposits, and total expenses. Similarly, we used interest and dividend income as output, besides non-interest income. The linear programming model shown above is run to identify the efficiency score of all DMUs. Each DMU selects input weights that maximize its efficiency score. Generally, a DMU is considered to be efficient if it obtains a score of 1.00, implying 100% efficiency, whereas a score of less than 1.00 implies that it is inefficient. It is to be noted that the technical efficiency comprises pure technical efficiency and scale efficiency. This requires the estimation of two DEA models — one with constant returns to scale (CRS) and the other with

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Table 1. Summary of notable studies on banks' efficiency (using the DEA approach)

Author(s)	Methodology	Units (DMUs)	Inputs	Outputs	Findings
Charnes *et al.* (1978)	DEA-CCR	DEA models applied in banking sector			Employed a CCR model to measure the technical efficiency, which was based on the concept of the Pareto optimum.
Banker *et al.* (1984)	DEA-BCC	DEA models applied in banking sector			They basically used the idea of DEA to identify the most efficient among all DMUs.
Hunter *et al.* (1990)	DEA	118 US commercial banks	Deposits	1-Interest income 2-Interest costs	There was no evidence of complementary cost and no subadditive cost functions.
Lang and Welzel (1996)	DEA	29 UK sector banks	1-Fixed assets 2-Deposits	1-Labor 2-Capital	All the selected banks enjoyed productivity, which was higher in small banks in the study sample.
Miller and Noulas (1996)	DEA	US large banks	1-Deposits 2-Fixed assets 3-Net worth	1-Advances 2-Loans 3-Investment	Larger and more profitable banks recorded higher levels of technical efficiency. At the same time, larger banks are more likely to operate under decreasing returns of scale.
Berger and Hemprey (1997)	DEA frontier efficiency	21 Countries	1-Revenues 2-Profits	Costs	Various efficiency methods did not necessarily yield consistent output and suggested some ways to improve.
Bhattacharyya *et al.* (1997)	DEA	70 Indian commercial banks	1-Advances 2-Deposits 3-Investments	1-Interest expense 2-Operating expense	Public-sector banks were most efficient, followed by foreign banks, and no trend in the efficiency of privately owned banks.
Athanassopoulos and Giokas (2000)	DEA	171 commercial bank branches of Greece	1-Borrowings 2-Deposits 3-Fixed assets 4-Net worth 5-Operating expenses	1-Advances 2-Loans 3-Investment 4-Net interest income	The results indicated the scope for substantial efficiency improvements.
Chen and Yeh (2000)	DEA	34 sample commercial banks	1-Borrowings 2-Deposits 3-Fixed assets	1-Advances 2-Loans 3-Investment 4-Net interest	The development of a more efficient and competitive banking sector should be encouraged in Taiwan and the inefficient commercial banks should make an effort to improve.
Richard *et al.* (2002)	DEA	US commercial banks	1-Deposits 2-Assets	1-Loans 2-Investments	Strong and consistent relationship between efficiency and independent measures of performance.

Continued

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Table 1. Continued

Author(s)	Methodology	Units (DMUs)	Inputs	Outputs	Findings
Spathis *et al.* (2002)	DEA	19 Greek banks	Deposits	Total assets	Though small banks seem more efficient and vulnerable, large ones have lower operating costs due to scale economies and their network.
Casu and Molyneux (2003)	DEA-VRS, CRS	European commercial banks	1-Total costs 2-Total deposits	1-Total loans 2-Earning assets	There has been a small improvement in bank efficiency levels.
Wang *et al.* (2005)	DEA-CCR	Top 200 banks in China	1-Capital 2-Total assets	1-ROE 2-ROA	According to CCR efficiency score analysis, it was found that two sample banks were relatively efficient. Private banks recorded higher efficiency than state-owned banks.
Asmild *et al.* (2006)	DEA	Large Canadian banks	1-Total advances 2-Total investments	Total deposits	Knowledge enabled the evaluation of productivity and provided a predictive tool for future projects.
Sufian and Majid (2007)	DEA	Listed Singapore commercial banks	1-Deposits 2-Assets	1-Loans 2-Investments 3-Non-interest income	During the period of study, small Singapore commercial banks were found to have outperformed their large and very large peers.
Arabinda (2008)	Descriptive and regression models	4 Large Bangladesh banks	1-Total advances 2-Total investments 3-Total income 4-Net profit	Total deposits	Commercial banks in Bangladesh had significant variation in profitability and productivity during the study period.
Avkran and Rowlands (2008)	DEA models		1-Interest expense 2-Non-interest expense	1-Net interest income 2-Non-interest income	There was a comprehensive approach where total input and output slacks were identified simultaneously for non-radial inefficiencies before leveling the playing field, identifying percentage adjustments attributable to the environment and statistical noise, and using a fully unit-invariant DEA model.
Debnath and Shankar (2008)	CCR and BCC model	50 Indian banks	1-Total assets 2-Deposits	1-PAT 2-Operating profit 3-Interest income 4-Advances 5-Total income	Estimated and compared the efficiency of banks in India; identified the priority areas for banks, which could improve efficiency.

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Table 1. Continued

Author(s)	Methodology	Units (DMUs)	Inputs	Outputs	Findings
Giokas (2008)	DEA	171 commercial bank branches in Greece	1-Borrowings 2-Deposits 3-Fixed assets 4-Net worth 5-Operating expenses	1-Advances 2-Loans 3-Investment 4-Net interest income	Results indicated the scope for substantial efficiency improvements.
Kumar and Gulati (2008)	CCR DEA model	27 PSBs for 2006/07	1-Physical capital 2-Labor 3-Loanable funds	1-Investments 2-Advances	Higher efficiency does not stand for higher effectiveness in public banks.
Lensink *et al.* (2008)	DEA models	2095 Commercial banks of 105 countries	1-Deposits 2-Assets	1-Loans 2-Investments 3-Non-interest income	Sample foreign banks were more efficient than their domestic counterparts, while the empirical evidence is generally opposite for developed countries.
Paul and Kourouche (2008)	BCC and CCR model-scale efficiencies	10 Australian banks for 1997	1-Interest expense 2-Non-interest expense	1-Net interest income 2-Non-interest income	Examined TE and found that the extent varied across the banks and over the years.
Yao *et al.* (2008)	DEA models	130 Chinese banks	1-Deposits 2-Bank staff 3-Assets	1-Loans 2-Investments 3-Non-interest income	The aggregate gaps in technical efficiency were low at only 15%. Further, the total factor productivity of sample banks rose significantly by 5.6% per annum over the data period.
Miencha and Selvam (2011)	BCC and CCR model-scale efficiencies	10 Kenyan banks for 2007–2010	1-Interest expense 2-Non-interest expense	1-Net interest income 2-Non-interest income	Evaluated TE and SE and found that the extent varied across the Kenyan commercial banks over the study period.
Minh *et al.* (2013)	DEA-VRS	32 Vietnam commercial banks	1-Investments 2-Deposits 3-Labor	1-Income 2-Interest 3-Loans	They found a small number of efficient banks. There was scope for these sample banks to improve their production efficiency. Further, large banks did not guarantee high super-efficiency scores in comparison with small banks.
DeYoung *et al.* (2013)	DEA models	US commercial banks	1-Total assets 2-Firm size 3-Market to book	1-Loans 2-Non-interest 3-Investment	US banks earned a larger percentage of their incomes from non-interest activities, invested a larger percentage of their assets in private (i.e., subprime or otherwise nonconforming) mortgage securitizations, and a smaller percentage of their assets in on-balance-sheet business loan portfolios.

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variable returns to scale (VRS). The model with CRS is known as the CCR model. If there is a difference in the two technical efficiency scores of a particular bank, this means that the bank's scale is inefficient (Ho and Zhu, 2004). Data envelopment analysis online software (DEAOS) was used for the purpose of calculating data for this study. CCR and BCC models were used to measure the volatility of banks' efficiency.

Limitations of the study

The present study has the following limitations:

1. We examined the technical efficiency and scale efficiency of Kenyan commercial banks and not the absolute efficiency.
2. We relied upon only secondary data and it was limited to only 20 sample banks.
3. The public-sector banks were fewer in number compared to the private-sector banks.
4. All limitations associated with the CCR and BCC models are applicable to this study.

Analysis of technical efficiency of commercial banks

For the purpose of this study, the analysis of technical efficiency of Kenyan commercial banks was carried out as follows:

- Analysis of technical efficiency based on the CCR model.
- Analysis of technical efficiency based on the BCC model.
- Scale efficiency scores of sample banks.

Analysis of technical efficiency based on the CCR model

The results of technical efficiency (through CCR, output oriented) analysis of commercial banks in Kenya during 2009/10 to 2012/13 are presented in **Table 2**. For the purpose of this study, data from all the 20 sample banks was compiled for the study period. The average technical efficiency of commercial banks during the study period ranged from 0.68 to 0.77, which clearly indicates that the banks in Kenya are moderately efficient. In 2009, the average efficiency score was 0.68. It is to be noted that five banks (namely Barclays Bank of Kenya, Equity Bank of Kenya, Trans National Bank of Kenya, CFC Bank of Kenya, and Commercial Bank of Africa) were considered efficient, with efficiency scores of 1.00, implying that these five banks had produced variable returns to scale on the efficiency frontier.

The sample banks such as National Bank of Kenya, Diamond Trust Bank of Kenya, Fidelity Commercial Bank, Giro Commercial Bank, Oriental Commercial Bank, United Bank of Africa, Victoria Bank, Kenya Commercial Bank, and Chase Bank earned efficiency scores of 0.81, 0.67, 0.80, 0.83, 0.64, 0.86 0.52, 0.68, and 0.84, respectively, implying that the National Bank of Kenya needs 0.19%, Fidelity Commercial Bank 0.20%, Giro Commercial Bank 0.17%, Oriental Commercial Bank 0.36%, United Bank of Africa 0.14%, Victoria Bank 0.49%, Kenya Commercial Bank 0.32%, Chase Bank 0.16%, and Diamond Trust Bank 0.33% of inputs (interest expenses, labor-related expenses, total deposits, and total expenses) to operate resourcefully on the efficiency frontier. It is surprising to note that other sample banks — namely Cooperative Bank of Kenya (0.11), Development Bank of Kenya (0.42), Family Bank of Kenya (0.41), Equatorial Bank of Kenya (0.31), Jamii Bora Bank of Kenya (0.41), and Credit Bank (0.26) — were less efficient in 2009. These banks required 0.99%, 0.58%, 0.59%, 0.69%, 0.59%, and 0.74% of inputs and outputs (interest and dividend income, non-interest income interest expenses, labor-related expenses, total deposits, and total expenses), respectively, indicating that they could have the same amount of inputs to become efficient. It is to be noted that only two banks (namely Cooperative Bank of Kenya and Credit Bank of Kenya)

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Table 2. Results of CCR/BCC formulation for commercial banks in Kenya

Sample banks	BCC		CCR		BCC		CCR		Scale efficiency			
	2009/10	2010/11	2009/10	2010/11	2011/12	2012/13	2011/12	2012/13	2009/10	2010/11	2011/12	2012/13
Public-sector banks												
National Bank of Kenya	0.81	0.83	0.57	0.33	1.00	0.99	0.77	1.00	0.69	0.58	0.44	1.00
Development Bank of Kenya	0.42	0.48	1.00	1.00	0.76	0.68	0.86	1.00	0.71	0.74	0.81	0.84
Private-sector banks												
Cooperative Bank of Kenya	0.11	0.86	0.81	0.22	0.45	0.75	0.65	0.90	0.46	0.54	0.55	0.83
Barclays Bank of Kenya	1.00	0.89	0.87	1.00	0.82	1.0	1.00	1.00	1.00	1.00	0.91	1.00
Equity Bank of Kenya	1.00	1.00	0.71	0.80	0.42	0.96	0.66	0.97	1.00	1.00	0.54	0.97
Commercial Bank of Africa	1.00	1.00	0.77	1.00	0.92	0.88	0.57	0.77	0.89	1.00	0.75	0.83
Family Bank of Kenya	0.41	0.45	0.65	0.90	1.00	0.94	0.81	0.65	0.53	0.67	0.91	0.80
Equatorial Bank of Kenya	0.31	0.82	1.00	1.00	1.00	0.99	0.87	1.00	0.66	1.00	0.94	1.00
Jamii Bora Bank of Kenya	0.41	0.42	0.66	0.97	1.00	0.99	0.71	0.66	0.53	0.69	0.86	0.83
Diamond Trust Bank of Kenya	0.67	0.76	0.26	0.22	0.72	0.66	1.00	0.26	0.46	0.49	0.76	0.46
Fidelity Commercial Bank	0.80	1.00	1.00	1.00	0.53	0.99	1.00	1.00	0.803	1.000	0.77	1.00
Giro Commercial Bank	0.83	0.92	0.85	0.93	0.88	0.78	0.85	0.85	0.983	0.983	0.87	0.82
Oriental Commercial Bank	0.64	1.00	0.73	1.00	0.33	1.00	0.73	0.73	0.941	1.000	0.53	0.87
Trans National Bank of Kenya	1.00	1.00	1.00	1.00	0.45	1.00	1.00	1.00	1.000	1.000	0.73	1.00
United Bank for Africa	0.86	1.00	0.95	1.00	0.83	0.99	0.95	0.95	0.904	1.000	0.89	0.97
Victoria Commercial Bank	0.52	0.71	0.73	0.74	0.86	0.78	0.73	0.73	0.711	0.964	0.80	0.76
CFC Bank of Kenya	1.00	0.53	1.00	0.84	0.89	0.79	1.00	1.00	1.00	0.63	0.95	0.90
Kenya Commercial Bank	0.68	0.88	0.86	0.99	1.00	0.98	0.86	0.86	0.79	0.89	0.93	0.92
Chase Bank	0.84	0.33	0.87	1.00	0.48	0.87	0.68	0.87	0.97	0.33	0.58	0.87
Credit Bank of Kenya	0.26	0.45	0.33	0.46	0.86	0.64	0.84	0.33	0.79	0.99	0.85	0.49
Average Score	0.68	0.77	0.72	0.81	0.76	0.88	0.83	0.83	0.79	0.82	0.77	0.86

Source: Central Bank of Kenya publications 2009–2013 and websites of respective banks.

were placed in the least-efficient category in 2009/10, with an efficiency score of 0.11 and 0.26, respectively.

Table 2 shows that the average efficiency score earned under CCR (output oriented) by all sample banks was 0.68 in 2009/10 and 0.77 in 2010/11. It is to be noted that out of the 20 sample banks taken for this study, only 6 banks (namely Equity Bank of Kenya, Commercial Bank of Africa, Fidelity Commercial Bank, Oriental Commercial Bank, Trans National, and United Bank of Africa) were considered to be efficient banks, with an efficiency score of 1.00. However, National Bank of Kenya, Cooperative Bank of Kenya, Barclays Bank of Kenya, Equatorial Bank of Kenya, Diamond Trust Bank of Kenya, Giro Commercial Bank, Victoria Commercial Bank, CFC Bank of Kenya, and Kenya Commercial Bank were moderately efficient, with efficiency scores of 0.83, 0.86, 0.89, 0.82, 0.76, 0.92, 0.71, 0.53, and 0.88, respectively, indicating that the National Bank of Kenya had to increase its variable return to scale by 0.17%, Cooperative Bank of Kenya by 0.14%, Barclays Bank of Kenya by 0.11%, Equatorial Bank of Kenya by 0.18%, Diamond Trust Bank of Kenya by 0.24%, Giro Commercial Bank by 0.8%, Victoria Commercial Bank by 0.29%, CFC Bank of Kenya by 0.47%, and Kenya Commercial Bank by 0.12% to become efficient banks. It is worth noting that the Development Bank of Kenya, Family Bank of Kenya, Jamii Bora Bank of Kenya, Chase Bank, and Credit Bank of Kenya earned least-efficient scores of 0.48, 0.45, 0.42, 0.33, and 0.45, respectively, which indicates that these banks should increase their variable returns to scale by 0.52%, 0.55%, 0.58%, 0.77%, and 0.55%, respectively, to be considered as efficient units.

Table 2 shows that the average efficiency score under BCC (output oriented) for all sample banks was 0.76 in 2011/12 and 0.88 in 2012/13. It clearly indicates that out of the 20 sample banks taken for this study, only 5 banks (namely National Bank of Kenya, Family Bank of Kenya, Equatorial Bank of Kenya, Jamii Boa Bank of Kenya, and Kenya Commercial Bank were efficient, with a score of 1.00. However, Barclays Bank of Kenya, Development Bank of Kenya, Commercial Bank of Kenya, Diamond Trust Bank of Kenya, Fidelity Commercial Bank, Giro Commercial Bank, United Bank of Africa, Victoria Commercial Bank, CFC Bank of Kenya, and Credit Bank of Kenya were moderately efficient, with scores of 0.82, 0.76, 0.92, 0.72, 0.53, 0.88, 0.83, 0.86, 0.89, and 0.86, respectively, showing that Barclays Bank of Kenya had to increase its variable return to scale by 0.18%, Development Bank of Kenya by 0.24%, Commercial Bank of Kenya by 0.8%, Diamond Trust Bank of Kenya by 0.28%, Fidelity Commercial Bank by 0.47%, Giro Commercial Bank by 0.12%, United Bank of Africa by 0.17%, Victoria Commercial Bank by 0.14%, CFC Bank of Kenya by 0.11%, and Credit Bank of Kenya by 0.14% to be considered efficient. Further, it is noted that Cooperative Bank of Kenya, Equity Bank of Kenya, Oriental Bank of Kenya, Trans National Bank of Kenya, and Chase Bank were inefficient, with 0.45, 0.42, 0.33, 0.45, and 0.48 score levels, respectively, needing to earn 0.55, 0.58, 0.77, 0.55, and 0.52 score levels, respectively, to be efficient. It is to be noted that during 2012/13, with the same CCR model, Barclays Bank of Kenya, Oriental Bank of Kenya, and Trans National Bank of Kenya had improved efficiency scores of 1.00. Also, during 2012/13 most of the sample banks improved, although there was fragmentation of the efficiency. The sample banks (namely National Bank of Kenya, Cooperative Bank of Kenya, Equity Bank of Kenya, Development Bank of Kenya, Commercial Bank of Kenya, Family Bank of Kenya, Equatorial Bank of Kenya, Jamii Bora Bank of Kenya, Diamond Trust Bank of Kenya, Fidelity Commercial Bank, Giro Commercial Bank, United Bank of Africa, Victoria Commercial Bank, CFC Bank of Kenya, Kenya Commercial Bank, Chase Bank, and Credit Bank of Kenya) earned scores of 0.99, 0.75, 0.96, 0.68, 0.88, 0.94, 0.99, 0.99, 0.66, 0.99, 0.78, 0.99, 0.78, 0.79, 0.98, 0.87, and 0.64, respectively. All needed to earn 0.1, 0.25, 0.4, 0.32, 0.12, 0.6, 0.1, 0.1, 0.44, 0.1, 0.22, 0.1, 0.22, 0.21, 0.2, 0.13, and 0.26 scores, respectively, to be efficient during the

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study period. It is significant to note that none of the banks were inefficient.

In light of the above analysis and from the feedback of bankers and bank managers, the government of Kenya and other policy-making bodies should take appropriate steps to improve the efficiency of weak banks — such as Cooperative Bank of Kenya, Development Bank of Kenya, Family Bank of Kenya, Equatorial Bank of Kenya, Jamii Bora Bank of Kenya, and Credit Bank of Kenya (as found in this study during 2009/10 and 2010/11). It is found that (see Table 2 for more information) the CCR model was second in rank score on the efficient frontier. The output maximization was less, with an indication of the score during the study period; the management of banks should establish a human resource development wing, with the latest technology, to improve the skills of employees in order to compete internationally.

Analysis of technical efficiency based on the BCC model

As shown in Table 2, the average efficiency score of sample commercial banks under CCR during 2009/10 and 2012/13 ranged from 0.72 to 0.81. The maximum score is 1. An efficiency score of, say, 0.72 automatically implies that an additional score of 0.28 is needed to achieve full efficiency. It is to be noted that, in 2009/10, the average efficiency of all the sample banks was at 0.721. Out of the 20 commercial banks, only three (namely Development Bank of Kenya, Equatorial Bank of Kenya, and CFC Bank of Kenya) were considered to be efficient, as the efficiency score of these three banks was 1.00, implying that they had produced their output on the efficiency frontier in 2009/10, whereas the other commercial banks (namely National Bank of Kenya, Cooperative Bank of Kenya, Barclays Bank of Kenya, Equity Bank of Kenya, Commercial Bank of Africa, Jamii Bora Bank, Giro Commercial Bank, Oriental Commercial Bank, United Bank of Africa, Victoria Commercial Bank, Kenya Commercial Bank, and Chase Bank) earned scores of 0.57, 0.81, 0.87, 0.71, 0.77, 0.65, 0.66, 0.85, 0.73,0.95, 0.73, 0.86, and 0.87, respectively, which indicates that these banks need an additional score of 0.43, 0.19, 0.13, 0.29, 0.23, 0.35, 0.34, 0.15, 0.27, 0.5, 0.27, 0.14, and 0.13, respectively, with the same amount of constant return to scale to be efficient. The least score of 0.26 and 0.33, showing inefficiency, was earned by Diamond Trust Bank of Kenya and Credit Bank of Kenya, which need 0.74% and 0.67%, respectively, with the same amount of constant returns to scale to be on the efficient frontier. The analysis of scores earned by banks during 2010/11 clearly reveals that there must be an improvement of efficiency in most banks.

During 2011/12, the average efficiency score of sample commercial banks under BCC was 0.83. Although there was high volatility of efficient banks, only five sample banks (namely Barclays Bank of Kenya, Diamond Trust Bank of Kenya, Fidelity Commercial Bank, Trans National Bank of Kenya, and CFC Bank of Kenya) earned an efficiency score of 1.00 in 2011/12, whereas other banks earned scores ranging from 0.65 to 0.86, indicating that those banks should increase their efficiency scores to be efficient. This shows that most of the banks are less efficient, in 2011/12. However, during 2012/13, seven banks improved their performance (namely National Bank of Kenya, Barclays Bank of Kenya, Development Bank of Kenya, Equatorial Bank of Kenya, Fidelity Commercial Bank, Trans National Bank of Kenya, and CFC Bank of Kenya).

By comparing the results under the CCR and BCC models, it was found that the banks (namely Development Bank of Kenya and Equatorial Bank of Kenya) were better, indicating that they operated on the efficient frontier. As shown in Table 2, banks had a relatively high score of efficiency frontier on the BCC model compared to the CCR model in the study.

Scale efficiency scores

In the case of the present study, the scale efficiency refers to a proportional reduction in input usage if the bank can attain the optimum production level where there are

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Table 3. Scale efficiency scores of commercial banks under CRS and VRS during the study period

Efficiency	2009/10	2010/11	2011/12	2012/13
Mean CRS efficiency	0.68	0.77	0.76	0.88
Mean VRS efficiency	0.72	0.81	0.83	0.83
Mean scale efficiency	0.79	0.82	0.77	0.86

Source: Central Bank of Kenya Annual Reports, 2009 to 2013.

constant returns to scale. Thus, the total technical inefficiency includes both managerial and scale inefficiency. Managerial inefficiency arises in cases where each input is used more than required to produce a given level of output. Such sub-optimal behavior is usually attributed to a lack of strong competitive pressures, which allows bank managers to continue with less-than-optimal efficiency. For the least and most efficient units in the sample, the efficiency measures take values between 0 (0%) and 1 (100%), respectively (Kyj and Isik, 2008).

The scale efficiency scores of banks during the study period are shown in **Table 3**. The banks' scores vary significantly between the variable returns to scale and constant returns to scale in scale efficiency during the study period. It is significant that in 2009/10 and 2010/11, the technical efficiency under VRS and CRS earned a mean score of 0.79 and 0.82, respectively.

Barclays Bank of Kenya, Equity Bank of Kenya, Trans National Bank of Kenya, and CFC Bank of Kenya are considered efficient, with a score of 1.00. Other banks (namely National Bank of Kenya, Development Bank of Kenya, Commercial Bank of Africa, Family Bank of Kenya, Equatorial Bank of Kenya, Jamii Bora Bank of Kenya, Fidelity Commercial Bank, Giro Commercial Bank, Oriental Commercial Bank, United Bank of Africa, Victoria Commercial Bank, Kenya Commercial Bank, Chase Bank, and Credit Bank of Kenya) earned moderate scores. The other sample banks (namely Cooperative Bank of Kenya and Diamond Trust Bank of Kenya) had earned a low scale efficiency score of 0.46, indicating that these two banks need 54% each with the same amount of input and output through VRS and CRS to be considered as efficient units. Similarly, the results for the years 2011/12 and 2012/13 are given in Table 3. It is significant to note that, during 2010/11 and 2012/13, there was an improvement of efficiency score for some banks. It is found that the scale efficiency of all sample banks shows an increase, except for the National Bank of Kenya, with a low score of 0.11. As pointed out earlier, it is emphasized that the respective bank managers should be empowered to improve their banking services and recruit skilled workers for better output.

Discussion and conclusion

The results reveal that some banks are inefficient and some are not operating at the optimal level. Our findings are in line with the results of Paul and Kourouche (2008), who found that the technical efficiency varied from bank to bank substantially in Australia. We have also found similar results in Debnath and Shankar (2008). The existence of scale inefficiency warrants that there is a need for restructuring the present banking sector, which may help the banks to compete globally. Barclays Bank of Kenya and Equity Bank of Kenya had the best efficiency level scores, whereas National Bank of Kenya had a negative value and, in the middle positions, Cooperative Bank of Kenya and Development Bank of Kenya showed positive changes with scores of 0.08 and 0.03, respectively. At the same time, the private banks showed a positive change in their scale efficiency throughout the examined period.

Overall, there is a need to improve the efficiency of banks in Kenya. To improve the efficiency of the banks, a number of policy measures at bank level and country level are required. There are avenues for future research in

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this area. For instance, future research can be carried out to answer research questions such as whether the differences in size have any relationship with scale efficiency. Government policies should encourage competition, greater use of technology, product diversification, and restructuring of banks by way of mergers and reorganization. It is suggested that the banks in developing countries such as Kenya may have to be well equipped to implement change management policies, with a focus on technical efficiency and productivity, which in turn will help them to achieve competitiveness. The efficiency of banks in developing countries needs to be improved by putting in all-round effort, in line with global standards. The managers of the banks are also required to adopt the latest banking technology to improve the output of banks and find a place on the efficient frontier.

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