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Working Paper

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KBA Centre for Research on Financial Markets and Policy Working Paper Series, No. 42

Provided in Cooperation with:
Kenya Bankers Association (KBA), Nairobi

Suggested Citation: Kiemo, Samuel; Kamau, Anne (2020) : Banking sector competition and intermediation efficiency in Kenya, KBA Centre for Research on Financial Markets and Policy Working Paper Series, No. 42, Kenya Bankers Association (KBA), Nairobi

This Version is available at:
https://hdl.handle.net/10419/249543

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May 2020

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Banking Sector Competition and Intermediation Efficiency in Kenya[1]

Samuel Kiemo* and Anne Kamau*

May 2020

Abstract

This paper seeks to evaluate efficiency and competition dynamics of the Kenyan banking sector for the period 2001-2017 using bank-level data for 37 commercial banks. To achieve this, the paper uses a three-step estimation approach; first, we apply non-parametric Data Envelopment Analysis (DEA) to analyze measures of various aspects of efficiency in the banking sector; secondly, we apply Panzar-Rosse, H-statistics model to assess competition in the banking sector; thirdly we introduce the DEA efficiency scores as an explanatory variable in the re-estimated P-R equation to capture the role of efficiency in competition. The study findings indicate efficiency was on an upward trend and averaging at 69 percent. The results also indicate Kenyan-banking sector is characterized by monopolistic competition as shown by H-statistics of 0.59. Managerial ability measured by DEA efficiency score is found to be an important factor in promoting competition for the Kenyan banking sector. The study reveals there is room for Kenyan banks to improve on efficiency by optimizing on scale of operations, managerial abilities and continual adoption of technology. Further, bank consolidation over the years seems to favor efficiency and competition gains in the sector, therefore, authorities should continue adopting policies that promote greater banking sector efficiency and competition.

Key Words: *Competition, Efficiency, Banks, H-Statistics, Data Envelopment Analysis*

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1.0 Introduction

A decade after the global financial crisis, policymakers' attention has shifted to evaluating whether the financial sector is more stable and if economies have fully recovered from the effect of the crisis. The focus is now more on how efficiency and competition can reduce fragility of the financial sector, amidst complexities brought by financial innovation, cross-border operations, interconnectedness and emerging regulations.

Locally, financial sector in Kenya has evolved over the last four decades to become the largest and most developed in the East African region. The evolution has largely been driven by major regulatory reforms implemented from 1990's, aimed at improving efficiency and spur competition in the banking sector. Financial innovation fueling rise of mobile money emergence, remain a distinct product of these reforms. The evolution also brought bank consolidations, interconnectedness and complexities due to cross-border operations. The debate is still on-going whether, the changing market power dynamics created very large and systemic banks ('too big to fail') and, highly interconnected banks ('too networked to fail') banks which can cause systemic risks in case of their instability.

However, all banking sector stakeholders agree the main objective of these financial sector reforms was to strengthen the resilience and sustainability of the industry. This was to be achieved by eliminating structural and regulatory issues limiting effective banking sector. Policymakers encouraged financial consolidation through voluntary or non-voluntary approaches in the banking sector aimed at increasing profitability, capitalization and efficiency due to economies of scale and exploitation of niche market segment.

Banks constantly aim to grow their market shares, profits, efficiency and asset bases, to outperform their competitors (Maudos 2017). Banks may achieve this through embracing reforms that result to changes in banking structure, mergers and acquisition, entry and exit of banks, conversion of non-bank institutions to banking institutions, adoption of technology and new business models. Banking sector competition in Kenya has largely been characterized by monopolistic competition[2] despite the number of banks in operation increasing since the 1990s (Long & Ombongi 2018, Mwega 2011, Talam & Kiemo 2017, Kamau 2009, Kamau 2011). However, in the recent past, the upward trend reversed with exit of some banks and with mergers and acquisition of others. These developments lead us to question whether the market structure has evolved with adoption of reforms over the years, whether there are other emerging competitive conditions and whether overall efficiency levels have improved in the banking industry.

The aftermath of Kenya's financial sector liberalization in the early 1990s, the banking sector experienced changing market power dynamics, for example, numerous mergers or acquisition transactions where twenty-eight mergers in 1990s, ten in 2000s and three in 2010s, have been completed. On other hand, two acquisitions in the 2000s and six in 2010's have also been finalized. These consolidations happened across all categories of the banking sector namely tier 1 –large peer group, tier 2 – medium peer group and tier 3 –small peer group. Increased capitalization, profitability, improved efficiency and assets quality of the banks were the expected results of these banking sector consolidations. Additionally, these reforms were expected to create strong institutions, which effectively compete among each other, ultimately lowering costs of financial services and products for customers. This brings us to question, what then is the evolving market structure? And has the market structure improved overall efficiency levels and competitive conditions?

Despite these development, the banking sector in Kenya still faces myriad of challenges including; comparatively high ratio of non-performing loans (NPLs) in some banks, insufficient quantities of commercial banks loans to finance long-term infrastructural projects, declining profitability, overreliance on large proportions of savings which comes from small depositors, skewed lending in favor of government, public and large entities and high interest rates spread till 2016[3] (Kiemo et.al 2019, Brownbridge 1998, Osborne, Fuertes & Milne 2015,

2. Assumptions of monopolistic competition include; many (producers) banks and many consumers in the market, with no bank having total control over the market price; consumers perceive there are non-price differences among the competitors' products; there are few barriers to entry and exit and the banks have a degree of control over price.

3. Interest rate cap law came into force and banks were required to lend at 4% above the Central Bank Rate, this led to a reduction in the spread.

Kithinji & Waweru 2007, CBK 2017). Policymakers are still grappling with formulation of the best policy options to promote efficiency hence improve competition in the banking sector. Alternatively, improve competition to enhance efficiency in banking sector.

Previous studies in Kenya on this topic have focused on efficiency and competition separately with the most recent study done in 2012 and its data series running to 2008. This paper then seeks to add value by incorporating more data points to 2017, a decade marked by bank sector reforms. Further, the paper jointly measures efficiency and competition using separate methods, then introduces the efficiency scores into the measure of competition, in an attempt to answer the question of whether efficiency plays a role in enhancing competition. This to the best of our knowledge has not been undertaken using Kenyan data. The paper will thus add and complement other studies in addressing the policy dilemma by evaluating the efficiency dynamics and market power interplay among the Kenyan banks using bank-level data.

1.1 Objectives of the Study

The objective of this paper is therefore threefold;

i) Firstly, the paper seeks to analyze the evolution of various aspects of efficiency in the Kenyan banking sector using DEA;

ii) Secondly, the paper seeks to assess the degree of competition conditions in the Kenyan banking sector using the Panzar-Rosse H-statistics;

iii) Thirdly, the paper seeks to examine the effect of efficiency on competition conditions in the Kenyan banking sector.

The rest of the paper is divided into six sections as follows. Section 2 provides an overview of the banking sector performance in Kenya. Section 3 reviews the literature on competition and efficiency. Section 4 presents the methodology and data issues. Section 5 discusses the results and section 6 provides conclusions and policy recommendations.

2.0 Overview of Banking Sector Performance in Kenya

Financial sector reforms were expected to spur efficiency and competition in the Kenya banking sector evidenced by increased capitalization, profitability, improved efficiency and assets quality, ultimately lowering costs of financial services and products for customers. However, the preliminary analysis does not largely support this claim. Despite the reforms from the late 1990s to date, key indicators show banking sector in Kenya has not gained much from these reforms.

Banking sector stability as indicated by capital ratios has been sound, high and above minimum CBK and Basel core principles requirement, however, the aggregate indicators camouflage a significant variation across different peer groups and individual banks. Overall Capital Adequacy Ratio (CAR) was 18 percent in 2019 up from 16.5 percent in the year 2006, indicating rising instability conditions. On downside, the banking sector experienced high levels of non-performing loans for many years before year 2006 averaging about 20 percent. However, the ratio declined significantly to the lowest level of 4.5% in year 2012 due to adoption of aggressive loan recovery strategies adopted by banks. However, the ratio has elevated to 12.3 percent as at year 2018 indicating elevated credit risks hence likelihood of bank experiencing financial instability (**Table 1**).

Table 1 Banks Financial Stability Indicators (%)

Selected FSI's	2006	2008	2010	2012	2014	2016	2017	2018
Capital Adequacy Ratio	16.5	18.4	20.8	21.9	20.0	19.8	18.8	18.7
Core Capital to Risk Weighted assets	16.4	16.2	18.7	18.9	16.0	17.0	16.5	17.2
NPL to gross loans Ratio	21.3	8.4	6.3	4.5	5.4	9.3	12.3	12.0
Return on Assets	2.8	2.9	3.7	3.8	3.4	3.3	3.2	3.1
Return on equity	28.6	28.6	30.7	34.2	26.6	24.6	25.8	27.6
Liquidity Ratio	30.5	34.6	38.4	35.2	32.7	41.8	43.7	50.7

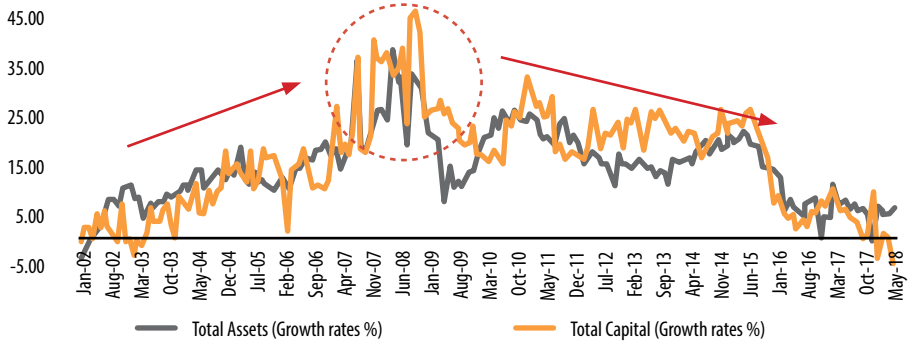
Source: Central Bank of Kenya (2019)

According to Kenya Financial Stability Report 2018, profitability has stagnated from 2008-2012 and has been on a downward trend from 2014 as shown by stagnation of banks ROA and ROE during 2008-2012 and eventual decline since 2012. On the other hand, the growth rate in capitalization ratios has stagnated from 2004 as indicated by core capital ratios. The ratio of core capital to total risk-weighted assets and core capital to deposits increased from 2001 to 2013, fueling banks assets growth. The pace of growth slowed significantly from 2014 to 2018. Stagnation of capitalization levels limits banks loans and deposits growth rate due to prudential limits on capital exposure (CBK 2019).

Similarly, total assets and total capital growth rate has been declining from the peak experienced in 2008. Prior to the year 2008, Kenya's banking sector grew rapidly in terms of assets and capital base reaching its peak in 2008 following reforms, strengthening of regulatory frameworks and improved business environment following liberalization in the 1990s. In 2008-09, the world faced Global Financial Crisis (GFC) that largely affected advanced economies and emerging markets. Kenya's banking sector was not directly affected by the GFC. However, in post-2008-09 crisis, the banking sector asset and capital growth took a downward trend, perhaps on account of portfolio flows, de-risking by global banking corporations from emerging and developing countries and tighter regulatory environment in global market (**Figure 1**).

On operational efficiency, banks have become more efficient as indicated by the ratio of overheads to total earnings and, the ratio of staff costs (including Directors' emoluments) to total earnings. Both these ratios have declined considerably since their peak in 2002 (**Figure 2**). This increased efficiency might be explained by reforms undertaken including

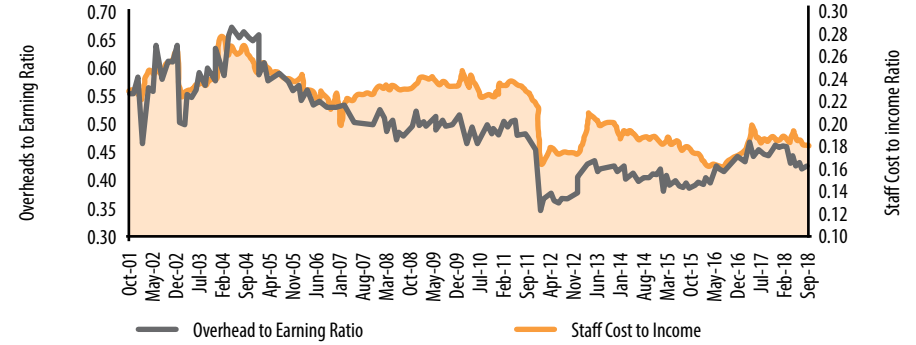
Figure 1: Banks Total Assets & Capital Growth Rate 2002-2018



Source: Central Bank of Kenya (2019)

consolidation, strong regulatory framework and adoption of technology and innovations by banks in providing banking services. Improved efficiency partially explains strong profitability in 2003-2012. However, slow growth in assets and reduced interest rate spread has lowered profitability since 2014. The decline in ROA and ROE reflects declining interest margin and narrowing spreads. Declined interest rates margin reflects a faster increase in interest expenses, relative to interest income.

Figure 2: Banks Efficiency from 2001-2018



Source: Central Bank of Kenya (2019)

Intermediation inefficiency has remained high as indicated by high-interest rate spread (bank loans lending rate minus customers deposit rate) and awash banking sector liquidity (CBK 2019). Interest rate spread has remained relatively high from 2004, which triggered the introduction of interest rate caps in 2016. Additionally, during the period 2012 to 2018, Kenya banking industry has been awash with liquidity. The average liquidity ratio for all banks increased above the minimum regulatory requirement of 20 per cent. This liquidity has largely been driven by government bonds, reflecting private sector intermediation inefficiency (**Figure 3**). The intermediation inefficiency may have been attributed to the rapid growth rates in non-performing Loans (NPL) over this period, reflecting deterioration of banks assets. The ratio of gross NPLs to gross loans has maintained a steady upward trend, signifying elevated credit risk in the banking industry (**Table 1**). Banks have responded to this risk by increasing provisions for bad debts, to the highest level in 2018 after the introduction of IFRS 9 that became operational in January 2018. This ultimately contributed to the declining profits discussed earlier (CBK 2019).

Market concentration measures of the banking sector indicate an industry that has shifted from oligopolistic competition to monopolistic competition with Concentration Ratio 5 (CR5)[4] moving from above 60 percent in 2001 to 47 percent in 2017. The shift from high concentration to low concentration implies that in general, competition in the banking sector is increasing putting more pressure on them to become more efficient in provision of services and products at competitive prices in order to remain profitable. The Herfindahl-Hirschman Index (HHI)[5] supports the finding of a sector that is becoming more competitive, that is, less concentrated over the same period, moving from an index of 1024 in 2002 to 675 in 2017 (**Figure 4**).

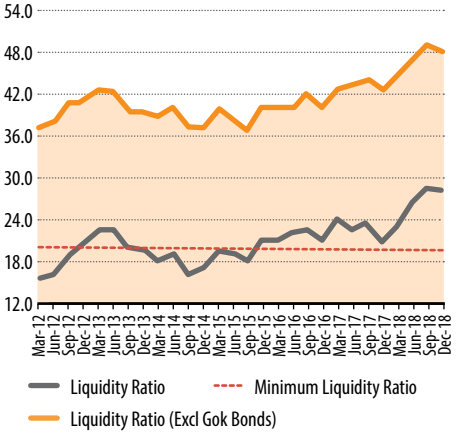
The financial sector reforms were largely expected to address all banking sector inefficiencies and improve financial sector resilience to financial shocks. This has not been largely addressed as the above trends indicate. This raises fundamental research questions on the appropriate policy stance aimed at promoting efficiency in the banking sector, hence spurring competition with the ultimate objective of achieving

4. CR5 is the sum of the market shares of the 5 largest banks in the market in question. The concentration ratio is calculated as the sum of the market share percentage held by the largest specified number of banks in an industry. The concentration ratio ranges from 0% to 100%, where 0% indicates perfect competion and 100% concentration is Monopoly. A rule of thumb is that an oligopoly exists when the top five firms in the market account for more than 60% of total market shares.

5. "HHI is the sum of the squares of the market shares of all banks in the market. It ranges from 0 to 10,000. The U.S. Department of Justice considers a market with an HHI of less than 1,500 to be a competitive marketplace, an HHI of 1,500 to 2,500 to be a moderately concentrated marketplace, and an HHI of 2,500 or greater to be a highly concentrated marketplace".

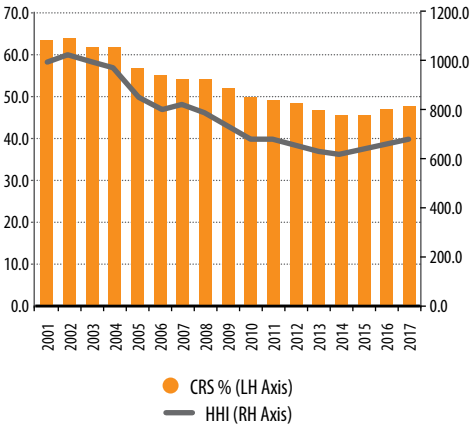
resilient and stable banking sector. This paper aims to contribute to this policy debate by exploring the evolution of the sector's competition and efficiency conditions. Also the paper examines the inter-linkages of competition and efficiency in the Kenyan banking sector.

Figure 3: Banking Industry Liquidity Ratios (percent)



Source: Central Bank of Kenya (2019)

Figure 4: Concentration Measures of Banking Industry in Kenya 2001 – 2017



Source: Author's Computations

3.0 Literature Review

Empirical literature on the inter-linkages between competition and efficiency is inconclusive. The first strand of literature focuses on the role of competition in promoting firm resilience from internal and external economic shocks through optimization and economies of scale.

Ultimately this leads to stability and efficiency in the industry. Proponents of the positive link between competition and stability assert that increased concentration through the mergers of many small institutions to few large institutions fosters stability by creating firms that can positively utilize economies of scale. Few big financial institutions are considered to be safer and less vulnerable to financial instability (Mlambo & Ncube 2011, Kamau 2011). This is achieved by reduction in information asymmetry problems and increase in inter-bank liquidity (Boyd & Nicolo 2005). However, some views argue that competition encourages risk-taking behavior by financial institutions increasing financial inefficiency). They argue increased market power, encourages banks to offer banking services at above-market prices, therefore moral hazard and adverse selection problems increase the riskiness of banks portfolios (Allen & Gale 2004).

The second strand of literature postulates the role of efficiency in influencing competition. This strand focus on how firms can utilize the gains from adopting far-reaching structural and operational changes geared to minimizing wastages in the firm activities.

6. Efficiency is defined in Economics as the production of maximum output from given inputs in a way that optimizes the use of resources available. The efficiency of the banking industry influences the cost of financial intermediation and the overall stability of the financial sector as banks constitute the backbone of financial markets in Kenya. Efficiency and scale of economies are known as two critical elements governing productivity in the banking sector (Novickyte 2018)

These gains allow firms to competitively price its output hence gaining a market niche. This strand of literature emphasizes that competition reduces monopoly through elimination of excessive banking prices and operational costs. This makes banks cost-efficient leading to increased gains to public by getting quality banking services at lower cost (Chen 2009). They argue that the bank's competitive advantage defines strengths of individual banks in a competitive environment depending on how banks react and actual position themselves in the market (Long & Ombongi 2018).

In the third strand of literature, competition is viewed to precede efficiency and triggers reallocation of profits towards more efficient banks. More efficient banks outperform less efficient ones in terms of profits thus fostering industry-wide efficiency. Several studies in advanced and emerging market support this view of positive causality running from competition to efficiency (Schaeck & Cihak 2014, Ajisafe & Akinlo, 2014, Nguyen & Nghiem 2018, Moyo 2018). Schaeck & Cihak 2014 study the European Banking system and find that competition improved bank stability via efficiency channel. Moyo (2018) furthermore finds that the impact of competition on efficiency of the South African banking sector depended on the measure of competition used. For instance, he finds Competition using Boone index enhanced bank soundness thus supporting the prudent and efficient management hypothesis.

Past empirical studies on financial reforms and efficiency postulate that financial reforms enhance the efficiency of banks by creating a competitive and flexible environment in which banks have more control of their operations. Thus improving technical, cost, profitability and allocative efficiency over the years (Ahmad 2011, Uddin et.al 2011, Kumar et.al 2016, Robin et al 2018). Earlier studies showed mixed results on impact of financial reforms, where they found that reforms may not have had any impact on efficiency of commercial banks Hao et al. (2001) and Yildirim (2002). Other relevant empirical literature has been summarized in **Table 2**.

Table 2: Summary of Empirical Evidence on the Linkages between Competition and Efficiency

Year	Author/s	Country/ies	Data	Methodology	Findings
2014	Schaeck and Cihak	European banks	1995-2005	Competition is expressed as a function of efficiency: using Boone (2008) indicator. Panel data models.	Competition incentivizes banks to enhance cost efficiency as it reallocates profits from unsuccessful (inefficient) banks to successful (efficient) ones. Competition improved bank stability via efficiency channel.
2014	Ajisafe and Akinlo	Nigerian banking sector	1990-2009	Panel Generalized method of moment	Competition in the Nigerian banking sector positively influenced the level of efficiency.
2018	Nguyen and Nghiem 2018	Vietnamese Banking Sector	2000-2014	Test the quiet life hypothesis as well as estimate the Lerner index and SFA to capture bank efficiency.	Improvement of competition and cost efficiency of the Vietnamese banking sector for the period of analysis. A positive causality running from competition to cost efficiency supporting the quiet life hypothesis.
2018	Novickyte L & Drozdz J	Lithuania	2012-2016	Non-parametric frontier input-oriented DEA technique with both VRS and CRS	Using VRS, better efficiency scores by local banks. Using CRS, the banks owned by the Nordic parent group and the branches have higher pure efficiency than local banks and have success at working at the right scale.
2018	Ouenniche J & Carrales S	United Kingdom (UK)	1987-2015	DEA with Regression-based feedback	Commercial banks operating in the UK whether domestic or foreign are yet to achieve acceptable levels of overall technical efficiency (TE), pure TE and Scale Efficiency (SE). DEA analysis with or without regression showed consistent findings.
2018	Horvatova E	Central and Eastern European Countries	2006-2013	Non-parametric DEA and Panel Regression	Found a weak association between the number of efficient banks and their belonging in the group of the Baltic countries. Panel regression results show that customer deposits had a positive impact on the technical efficiency of banks during the financial crisis.

4.0 Research Methodology

4.1 Measurement of Efficiency

Empirical literature on bank efficiency proposes several frontier approaches in measuring efficiency that may be formulated in parametric or non-parametric forms. These include Data Envelopment Analysis (DEA), Stochastic Frontier Approach (SFA) or Distribution Free Approach (DFA) (Kamau 2009, Mlambo & Ncube 2011, Titko & Jureviciene 2014, Ouenniche & Carrales 2018).

This paper uses non-parametric DEA which does not require apriori functional form for the frontier but assumes a simple piecewise linear connections of units on the frontier. DEA[7] measures the technical efficiency with the focus on levels of inputs relative to outputs given a sample of homogenous decision-making units (DMUs). The distance between the observed data point and the frontier measures the relative inefficiency of each DMU. Efficient DMU's form the frontier, while less efficient DMU's are located inside the frontier. Therefore, efficiency score is measured as a ratio of the weighted sum of outputs to the weighted sum of inputs. For any DMU in the sample, this ratio is equal or less than one (1), where those with efficiency score of one (1) are relatively efficient and make up the frontier, while those with score below one (1) are relatively inefficient.

To measure efficiency in the Kenyan-banking sector, we use the output-oriented DEA model with the variable returns to scale and constant returns to scale assumptions (Charnes et.al 1978, Banker et.al 1984) thus distinguishing two

7. The initial DEA model was presented by Charnes et al (1978) that build on Farrell's seminal paper of 1957 on "the measurement of productive efficiency". The CCR (Charnes, Cooper and Rhodes) model assumed that the production technology and the so called production possibility set exhibited constant returns to scale (CRS). They also presented the models in two orientations input or output Input-oriented approach assumes banks maximize the use of inputs for a given set of outputs. Output-oriented approach assumes a bank produces the highest possible output given set of inputs. The model by Charnes et.al (1978) was later modified by (Banker et al 1984) by introducing the Variable Return to Scale (VRS).

different kinds of efficiency –technical and scale efficiencies. The choice is based on the fact that commercial bank managers tend to have more control over the outputs, such as loans and investments rather than inputs such as deposits. DEA model estimates the efficiency score for individual DMU by solving the linear programming (LP) equation.

The choice of bank inputs and outputs to use is guided by banking literature that shows three commonly followed approaches namely; production, intermediation and profitability. Production approach assumes banks employ inputs such as labour and capital to produce output such as loans and investments. The intermediation approach takes into account the role banks plays in the intermediation process between depositors and borrowers. Banks are also profit seekers, and must effectively manage risks, deposits and costs to remain profitable (net interest income, operating profit, net profit) that results from efficient use of inputs.

The rule of thumb for the selection of the model is Paradi et al (2018), DMUs should be at least three times larger than the total number of inputs plus outputs used in the models. The models showing the different input-output combinations for the three approaches discussed are presented in **Table 3**:

Table 3: DEA Models with Different Input-Output Combinations

Model	Inputs	Outputs	Approach
M1	Deposits and labour costs	Gross loans and investment	Intermediation
M2	Labour and capital	Gross Loans and investments	Production
M3	Deposits and Labour	Net interest Margin/operating profit	Profit

DEA's model formulation is as follows; following notations by Barr et al., (1994). DEA extrapolates Ferrell's (1957) single-output to single-input technical measure to a multiple-output to multiple-input technical measure. This model assumed that jth DMU uses a 'm' dimensional input vector, xij (i = 1,2,...m) to produce a 'k' dimensional output vector, yrj (r = 1,2,...,k). The DMU under evaluation is denoted by '0' as shown in equation 1 below.

$$w_0 = \frac{\sum_{r=1}^{k} u_r y_{rj0}}{\sum_{i=1}^{m} v_r x_{ij0}} \quad \text{..... (1)}$$

where w_0 is the relative efficiency, x and y are the input and output vectors respectively, and u_r and v_i are the weights of output r and input i. The above ratio accommodates multiple inputs and outputs in efficiency estimation and measures the relative efficiency based on input and output weights. The respective weights for each DMU should be derived using the actual observed data instead of fixing in advance (Cooper, et al., 2000). CCR introduced the following fractional programming problem to obtain values for input weights and output weights. Basic CCR formulation is derived in equation 2.

$$Max\ w_0 = \frac{\sum_{r=1}^{k} u_r y_{rj0}}{\sum_{i=1}^{m} v_r x_{ij0}}$$

Subject to

$$\frac{\sum_{r=1}^{k} u_r y_{rj0}}{\sum_{i=1}^{m} v_r x_{ij0}} \leq 1, \text{ for each j} = 1,...n$$

$u_r v_i \geq 0$ r=1,…..,k. i=1,….,m

..... (2)

where w_0 is the relative efficiency, x and y are the input and output vectors respectively, u_r and v_i are the weights of output r, and input i, n, m and k denote the number of DMUs, inputs and outputs respectively. The above fractional programming problem is based on the objective to estimate the optimum input and output weights for each DMU under evaluation. It measures the relative efficiency of DMU_0 based on the performance of the other banks in the industry. For that, the weighted input and output ratio is maximised subject to given constraints. The first constraint of the model limits the estimated efficiency of the DMUs to one. The second constraint in the above model indicates that all variables, including input and output weights, are non-negative. Estimated input and output weights are used to find the efficiency index *'w'*. The fractional programming problem is then transformed into a linear programming model (CCR), as illustrated in equation 1 in the appendix. The BCC formulation follows in equation 2 in appendix.

The BCC model has the VRS assumption that distinguishes it from CCR which has a CRS assumption. The VRS assumption takes into consideration the scale of operation and measures pure technical efficiency. Using the BCC model one may be able to derive the Scale efficiency:

$$\text{Scale Efficiency} = \frac{\textit{Technical Efficiency from CRS}}{\textit{Technical Efficiency from VRS}}$$

4.2 Measurement of Competition

Studies on competition have largely led to a distinction between two measures of competition namely; structure-conduct-performance and non-structure-conduct-performance models (Mwega 2011, Talam & Kiemo 2017). According to structure-conduct-performance model, the market structure drives conduct and performance of banks in the sector. Commonly used structure conduct measures of competition are; Herfindahl-Hirschman index (HHI) and the concentration ratios (CR). Concentration ratio (CR) indicates the market structure of 'M' banks in the economy, where "M" is the number of largest banks. It uses market share of the M to indicate the degree of oligopolistic competition in an economy. Major limitations include; omitting market share of all banks and heavy reliance on a few large banks, hence it endogenously determines the result, to some extent. Additionally, it does not consider other important information such as distribution of the bank size, business model, and other indicators of bank performance. Limitations of CR led to development of Herfindahl-Hirschman index (HHI) which measures a bank's size in relation to the industry. The HHI is the sum of the squares of the market share of each participant in the market. This ratio is considered a standard tool of measuring concentration, as it gives more weight to larger banks. However, structure-conduct-performance models have been criticized since they are based on the assumption that higher market power indicated by high ratios, results in super-normal profits due to monopolistic tendencies. Further, they ignore other factors that may impact competition.

On the other hand, non-structure-conduct-performance models competitive measures attempt to address limitations of structural measures by incorporating other micro-economic conditions affecting firm's competitive conditions. Commonly used non-structure-conduct-performance models are the Lerner Index, the Boone Indicator and, Panzar-Rosse H-statistics. Lerner Index proposed by Lerner (1934) measures competition by describing the relationship between prices and costs for profit-maximizing firms. Lerner Index major limitations are that gathering the necessary information on prices and costs of firms is almost impossible. On other hand, Boone Indicator proposed by Boone (2008) assesses how firms efficiently utilizes the inputs for profit maximizations. Boone Indicator reveals how competition improves the performance of efficient firms and abate the performance of the inefficient firms by concentrating on the efficiency's impact to the performance in terms of profit and firm's market shares (Tusha & Hashorva 2015). The empirical debate is still ongoing effectiveness of Boone Indicator in measuring competition.

In the empirical literature, the most popular measures of competitions currently remain as Panzar-Rosse (P-R) H-statistics developed by Panzar & Rosse (1987), as a measure of competition conditions. The P-R model uses marginal behaviour/conduct to assess the degree of competition amongst firms. Under

perfect competition, an increase in input prices raises both marginal costs and total revenues by the same amount as the rise in costs. Under a monopoly, an increase in input prices will increase marginal costs, reduce equilibrium output and consequently reduce total revenues. The P-R model provides a measure ("H-statistic") of the degree of competitiveness of the industry, which is calculated from reduced form bank revenue equations as the sum of the elasticities of the total revenue of the banks with respect to the bank's input prices.

The H-statistic falls between 0 and 1, where closer to 0 is collusive (joint monopoly) competition, closer to 1 indicates monopolistic competition and 1 is perfect competition. According to Gutiérrez (2007), a critical feature of the empirical implementation is that the test must be undertaken on observations that are in long-run equilibrium. In previous studies, testing for long-run equilibrium involves the computation of the H-statistic in a reduced-form equation of profitability, using a measure such as ROE or ROA in place of revenues as the dependent variable. The resulting H-statistic is supposed to be significantly equal to zero in equilibrium, and significantly negative in case of disequilibrium. This empirical test has traditionally been justified on the grounds that competitive markets will equalize risk-adjusted rates of return across firms such that, in equilibrium, rates of return should not be correlated statistically with factor input prices.

This paper adopts Panzar-Rosse (1987) methodology, the (P-R) H-statistics, to measure competition conditions. This model assumes the banks' main objective is to maximize profits while operating in contestable market-facing conventional cost curves. Two-stage model estimation approach was used. The first stage involves testing equilibrium positions in the data. This is occasioned by the fact that P-R approach is static in nature, which is a major limitation. The empirical applications require that the long-run equilibrium is observed. Equilibrium test by empirical studies has been performed by replacing the dependent variable by revenue variables such as ROA or ROE. A similar approach was followed by Mwega (2011), Mlambo & Ncube (2011), Ombongi & long (2018). We estimated the reduced form equation for Kenya to test long-run equilibrium conditions in the data, as indicated in equation (3).

$$\ln(\mathrm{ROA}_{i,t}) = \alpha + \beta_1 \ln(w1_{i,t}) + \beta_2 \ln(w2_{i,t}) + \beta_3 \ln(w3_{i,t}) + y_1 \ln(npl_{i,t}) + y_2 \ln(bsize_{i,t}) + y_3 \ln(inf_t) + y_4 \ln(tbill_t) + \varepsilon_{i,t} \quad \text{..... [3]}$$

Where $\mathrm{ROA}_{i,t}$ is the rate of return proxied by the ratio of net income to the total asset. The second stage involves estimating similar to the manner prescribed by Panzar-Rosse (1987) as shown in equation (4).

$$\ln(P_{i,t}) = \alpha+\beta_1 \ln(w1_{i,t}) + \beta_2 \ln(w2_{i,t}) + \beta_3 \ln(w3_{i,t}) + y_1 \ln(npl_{i,t}) + y_2 \ln(bsize_{i,t}) + y_3 \ln(inf_t) + y_4 \ln(tbill_t) + \varepsilon_{i,t} \quad \text{..... [4]}$$

Where P is the output price of loans, proxied by the ratio of gross interest revenue over total assets, $w1$ is the input price of funds proxied by gross interest expense over total deposits, $w2$ is the input price of labour proxied by ratio of salaries and wages to total assets, $w3$ is the input price of capital/equipment proxied by ratio of non-interest operating income to total assets. As control variables, npl computed as the ratio of non-performing loans over total loans is included as a proxy for banks credit risk, bsize, which is total assets is included as a proxy for size. Inflation (inf) and the 91-day Treasury bill rate ($tbill$) are included as a proxy for the macroeconomic environment. i and t represent cross-sectional and time dimensions. H-Statistic is derived as the summation of $\beta 1+\beta 2+\beta 3$, the coefficients of factor input elasticity's prices from equation [4]. Additionally, γ, β and γ represented coefficients of regressors.

The signs of the factor input prices in standard practice is difficult to assign *a priori*, while for two bank-specific variables $lognpl$ and $lnbsize$ are expected to have negative and positive signs respectively. For the macro-economic variables, $logtbill$ and $loginf$ are both expected to have positive and negative signs respectively.

4.3 Role of efficiency in Competition

To achieve the third objective, the paper introduces the DEA efficiency scores generated as an explanatory variable in the re-estimated Panzar-Rosse (P-R) equation [4] to capture the role of efficiency in competition. The equation is estimated as indicated in equation [5].

$$\ln(P_{i,t}) = \alpha+\beta_1 \ln(w1_{i,t}) + \beta_2 \ln(w2_{i,t}) + \beta_3 \ln(w3_{i,t}) + \lambda(DEA_{i,t}) + y_1 \ln(npl_{i,t}) + y_2 \ln(bsize_{i,t}) + y_3 \ln(inf_t) + y_4 \ln(tbill_t) + \varepsilon_{i,t} \quad \text{.....[5]}$$

Where DEA is the efficiency score and λ is the coefficient of the efficiency score

4.4 Data and Population

The study makes use of annual bank data for 37 banks for the 17 years under study (2001-2017). The data has been collected from the balance sheets and income statements reported by the commercial banks and published in the Central Bank of Kenya Annual Bank Supervision Reports. Due to mergers, entrants and exit of commercial banks in the industry, 6 banks were dropped from the sample whose data sets were less than 8 years.

5.0 Results and Empirical Findings

5.1 Empirical Results: Evaluating Efficiency of Kenyan Banks

To address the first study objective, we used a variable returns (VRS) output-oriented DEA methodology to measure the efficiency of Kenyan Banks. The importance of using the VRS assumption is that it yields the pure technical efficiency DEA scores that explain efficiency resulting from managerial efficiency.

We follow the intermediation approach (M1 in **Table 3**) that considers that banks play the role of intermediation between depositors and borrowers. Hence deposits and labour costs are considered as inputs whereas investments and advances are considered as outputs. The Data Envelopment Analysis program (DEAP) by Coelli version 2.1 is used to compute efficiency measures presented in **Table 4** and **5**. The Malmquist DEA is used to compute the efficiency measures such as overall technical efficiency (OTE), pure technical efficiency (PTE) and scale efficiency (SCE) measures

Table 4 shows a summary of the DEA results for the Kenyan banking sector in the period 2001-2017. The results show that average technical efficiency ranges between 55 percent (2006) and 81 percent (2015). In the sample period of 2001-2017, the average technical efficiency in Kenyan banks was 69 percent, suggesting that on average the banks could produce outputs with approximately 31 percent fewer inputs.

Table 4: Summary of the DEA Results for the Kenyan Banking Sector -Period 2001-2017

Year	No. of banks at frontier	Average Technical Efficiency (μ)	Average inefficiency (1-μ/μ)	Standard dev. of inefficiency (δ)	Interval (μ−δ;μ+δ)	Percentage of banks in the interval
2001	4	0.67	0.50	0.221	(0.44-0.88)	65%
2002	6	0.63	0.58	0.227	(0.40-0.86)	62%
2003	4	0.64	0.56	0.234	(0.41-0.88)	62%
2004	3	0.65	0.55	0.224	(0.42-0.87)	62%
2005	4	0.62	0.62	0.206	(0.41-0.82)	65%
2006	4	0.55	0.82	0.214	(0.33-0.76)	73%
2007	8	0.77	0.30	0.197	(0.57-0.96)	62%
2008	5	0.70	0.42	0.234	(0.47-0.93)	59%
2009	4	0.69	0.44	0.214	(0.48-0.91)	59%
2010	3	0.69	0.44	0.187	(0.51-0.88)	68%
2011	5	0.73	0.38	0.181	(0.54-0.90)	59%
2012	7	0.76	0.32	0.206	(0.55-0.96)	57%
2013	8	0.77	0.29	0.182	(0.59-0.95)	54%
2014	9	0.77	0.29	0.185	(0.59-0.96)	57%
2015	7	0.81	0.23	0.157	(0.65-0.97)	54%
2016	7	0.62	0.61	0.225	(0.39-0.84)	59%
2017	7	0.64	0.55	0.229	(0.41-0.83)	57%
Mean		0.69	0.46			61%

Source: Authors computations from DEA program

In **Table 5**, the average pure technical efficiency ranges from 72 percent (2006) and 89 percent (2014) efficiency. On average, banks were 18 percent inefficient under variable returns to scale and 16 percent scale inefficient. Alternatively, the results suggest that for the last 17 years, banks would have increased output by 31 percent and 18 percent had they been 100 percent efficient. The results, however, show improvement of efficiency in the Kenyan banking sector when compared to a previous study that showed banking inefficiency stood at 44 percent constant return to scale and 35 percent variance return to scale in 2009 (Kamau 2009). Implying reforms, adoption of technology and changing business models are greatly improving efficiency in the banking sector. Furthermore, there is still some scope for the commercial banks to increase their output if they operate at optimal efficient levels – at the frontier.

Whereas comparisons of other findings may require that same orientation and variables be analyzed for the same period, past studies on efficiency measures in the banking industry show diverse results. Our results however closely relate to those found in South African Banking sector Mlambo & Ncube (2011) found an efficiency score of 0.85 for 8 banks including 5 largest banks and Kiyota (2009) who found average efficiency score of 0.48. Our result is also similar to Sanderson & Bara (2017), who found a score of technical efficiency of 82.9 percent during the period 2009-2015. This result implies that the average commercial bank suffered a 17.1 percent level of technical inefficiency.

Table 4 also shows that from 2001 to 2014, the number of banks at the frontier (that is banks with a DEA efficiency score of unity) has been increasing and peaked at 9 in 2014, declining to 7 and stabilizing at 7 for 2015-2017. A further analysis, reveals for most years, the tier 2 banks dominated the banks at the frontier, with tier 3 banks increasing their presence at the frontier as years progressed (see Table 1 in appendix). The percentage of banks falling within the inefficiency range of one standard deviation around the mean is lower at the end of study period which was 56 percent in 2017 than at the beginning 65 percent 2001, implying more banks are improving their efficiency in operations. Thus, we may conclude that Kenyan-banking sector is becoming more relatively efficient over time.

Table 5: Pure Technical and Scale Efficiency 2001-2017

Year	Pure Technical Efficiency	Scale Efficiency
2001	0.82	0.81
2002	0.77	0.82
2003	0.76	0.85
2004	0.76	0.85
2005	0.76	0.82
2006	0.72	0.76
2007	0.85	0.91
2008	0.79	0.89
2009	0.81	0.86

Year	Pure Technical Efficiency	Scale Efficiency
2010	0.87	0.80
2011	0.88	0.83
2012	0.89	0.85
2013	0.91	0.85
2014	0.89	0.87
2015	0.88	0.92
2016	0.77	0.81
2017	0.80	0.81
Mean	0.82	0.84

Source: Authors computations from DEA program

Table 5 also shows improvement of scale efficiency and pure technical efficiency under VRS has been improving over the years. This implies banks are improving on the benefits accruing from economies of scale of production through optimizing their scale of operations. Evidently results in Table 4 and 5 show a slight slowdown of efficiency scores for the last two years (2016-2017) which we attribute to the introduction of interest caps and the closure of some banks during the years.

Overall, the results mean that inefficiency of commercial banks results more from pure technical inefficiency rather than from scale inefficiency as indicated by measures of 18 percent and 16 percent inefficiency. Commercial banks may improve their efficiency if they optimized the scale of operations to shift to increasing returns to scale, as well as gain from improving their pure technical efficiency by improving managerial skills and/or adoption of technology to deploy resources to their best optimal use.

However, there is a caution in interpreting the results. As much as there are many advantages[8] in using the DEA methodology, there are also some caveats readers must take into consideration.

One is that the efficiency measurements obtained are sensitive to choice of orientation used, that is either CRS or VRS which give different results, as the CRS takes a long term view while the later VRS takes a short term view of production process. Second, the DEA results are sensitive to choice of inputs and outputs used. Depending on what a particular study aims at attaining, the selected inputs and outputs will yield different results. Third, it is not possible to test the best specification beforehand, as in, the frontier is derived from data used hence conditioned to a particular data set. Fourth and finally, the number of efficient banks at the frontier seems to increase with the number of inputs and output variables. Because of these shortcomings, it becomes difficult to compare past studies on the same topic as all the specifications have to match before comparison can be done.

8. Some advantages are mentioned in the methodology section; for instance, there is no need to explicitly specify apriori functional form; the methodology is useful in uncovering relationships that are not easily detectable in other methodologies; the methodology handles several inputs and outputs at the same time in any/various combinations and one can analyze the sources of inefficiency for each unit/bank.

5.2 Empirical Results: Evaluating Competition of Kenya Banking Sector

5.2.1 Diagnostic Tests

To address the second study objective, we estimate equation [3] and [4] to assess competition conditions in Kenya. However, prior to undertaking regression analysis, data specification diagnostic tests were conducted to determine the suitability of the data. The tests were to verify if the panel data violated the ordinary linear squares (OLS) classical assumption on stationarity. Panel unit root test, Levin, Lin & Chu (LLC) (2002) was applied on the study variables to determine the stationarity of the panel data. LLC test allows the degree of persistence in individual regression error, the intercept and trend coefficient to freely vary across individual data. The LLC test revealed the variables lnp, lnw1, lnw2, lntbill and lninf were stationary on level, while lnbsize, lnw3, lnnpl and lnroa were stationary on first difference (Table 6). Other unit root tests namely; Breitung t-stat, Im-Pesaran & Shin W-stat (IPS), Fisher-Chi Square-ADF (Fisher ADF), and the Phillips-Perron Fisher-Chi Square-PP (Fisher PP) were undertaken and revealed similar results to LLC.

Table 6: Panel Unit Root Test Results

Variables	Levin, Lin & Chu t-Statistic	Prob.**	Cross-sections	Obs
lnp	-7.294***	0.000	37	551
lnroa	-14.628***	0.000	33	408
lnw1	-12.756***	0.000	37	551
lnw2	-5.759***	0.000	37	551
lnw3	-8.421***	0.000	37	513
lnnpl	-5.441***	0.000	37	509
lnbsize	-5.819***	0.000	37	518
lntbill	-30.790***	0.000	37	555
lninf	-17.534***	0.000	37	555

*** 1% level of significance. Null hypothesis: Series contains unit root. The p-value distribution assumes Chi-square asymptotic normality.

Table 7: Hausman Test for Model Effects Estimation

	Chi-Square Statistic	Degree Freedom.	P-Value
Cross-section random	11.683	8	0.166

Null Hypothesis: Random Effects Model is Appropriate: Significance level 5 Percent

We adopted the dynamic panel data Generalized Method of Moments (GMM) estimator. We adopted a panel approach to enable us to observe the behaviour of the different study units (37 banks) over the study period by accommodating the joint presence of dynamics and unobserved heterogeneity. The panel estimators provide solutions to cross-sectional specific problems besides permitting the use of instrumental variables to contain the potential joint endogeneity of the explanatory variables. On other hand, the GMM estimator eliminates measurement errors, endogeneity problems and omitted variables issues through availing additional moment restrictions (Arellano and Bond 1991, Newey & West 1987).

Panel data estimation models . may adapt three techniques namely; pooled regression model, fixed effect model and the random effect models. Pooled model is mostly applicable where it involves pooling all the data for running an ordinary least square (OLS) since cross-sectional or temporal effects are not significant. For this study, this is not the case hence the need to establish cross-sectional effects. We followed Hausman (1978) recommendation and estimated Hausman test for fixed / random effects model estimation to establish most appropriate model between the fixed effect model (FEM) and random effect model (REM). This is a test statistic for endogeneity by directly comparing fixed and random effects estimates of coefficients values.

The Hausman test results indicated by Table 7 shows the Chi-Square test statistics of 11.68 with the corresponding 8 degrees of freedom and 0.166 percent p-value for the panel model equation. The P-values reveals that the results were not statistically significant at 5 percent significance level hence we failed to reject the null hypothesis.

5.2.2 Testing for Long-Run Equilibrium

To test for the long-run equilibrium in the computation of the H-statistic, we estimated equation 3 with ROA as the dependent variable to determine the E-statistic. The E-statistic was derived as the summation of $\beta1+\beta2+\beta3$, the coefficients of input price elasticities. Table 8 present a summary of H-Statistics and E-Statistics value interpretation. Additionally, Table 9 presents estimates of equilibrium equation.

Table 8: H and E Statistic Value Interpretation

Equilibrium Test	
1st Condition E=0	Equilibrium
2nd Condition E<0	Disequilibrium or non-existence of equilibrium
Competitive Conditions	
1st Condition H<0	Oligopolistic or short run competition, collusive oligopolistic competition
2nd Condition H=1	Perfect Competition
3rd Condition 0<H<1	Monopolistic Competition.

Testing whether the Kenya banking sector is in equilibrium or disequilibrium in long-run is a preliminary condition for estimating P-R H-statistics. Table 9 column A, revealed the E-statistics value was -0.2933, which can be deduced to mean there exists no equilibrium in Kenya's banking sector during the study period.

However, to confirm state of equilibrium, we estimate Wald-Statistic (F-Test) for E=0, against the alternative hypothesis $E \neq 0$. The results indicate that we cannot reject the null hypothesis at 5 percent significance level. This means equilibrium holds during the study period. These results confirm Ombongi & long (2018) findings on Kenya of E-statistics of -0.027 for years between 1994 and 2016. The table also reveals that regressors' coefficients for logw1, logw2, lnnpl, and lntbill were negative. This indicates increase in these variables in long-run affects bank's profitability negatively. On the other hand, the coefficients of regressors' lnw3, lnbsize and lninf were positive indicating increase in these variables in long-run positively increases bank's return. The coefficients of all regressors except lntbill and lnnpl were found to be significant at 10 percent confidence level.

5.2.3 Estimating Competition Measure H-statistic

After satisfying the long-run equilibrium condition, we estimated equation 4 to compute H-statistics and results are presented on Table 9 Column B. The findings (Table 9 Column B) revealed that H-statistics 0.59, derived after sum of input factors lnw1, lnw2 and lnw3 coefficients. The coefficients of the input price of funds (lnw1) and coefficients input price of labour (lnw2) were found to be positive and significant at 1 percent. This indicates that these two-factor input variables positively affect the output price of bank loans (p) in Kenya. The coefficient of the input price of capital (lnw3) was negative but not statistically significant, indicating the input prices of capital negatively affect output price of bank loans (p) in Kenya, however the effect is not statistically significant.

5.3 Empirical Results: Evaluating Role of Efficiency in Competition

To address the third study objective, we followed Mlambo & Ncube (2011), Casu & Girardone (2006) approach and to estimate equation [5], which introduces the DEA efficiency scores generated as an explanatory variable in the re-estimated Panzar-Rosse (P-R) equation [4] to capture the role of efficiency in competition and results presented in Table 9, Column C. Introduction of DEA efficiency scores is taken as proxy for managerial ability.

Table 9: Panel Regression Results of competition Conditions in Kenya Banking Sector

	Second Objective		Third Objective
	A	B	C
Dependent Variable	lnROA	lnP	lnP
Intercept	-3.622***	-0.322**	-0.239*
	(-10.26)	(-2.48)	(-1.80)
Lnw1	-0.084**	0.345***	0.341***
	(-2.22)	(23.70)	(23.94)
Lnw2	-0.403***	0.262***	0.280***
	(-5.23)	(9.40)	(8.48)
Lnw3	0.194***	-0.020	-0.034
	(3.11)	(-0.903)	(-1.49)
lnnpl	-0.060	0.003	-0.002
	(-1.00)	(0.10)	(-0.10)
lnbsize	0.509***	0.116*	0.128*
	(2.85)	(1.72)	(1.89)
lntbll	-0.031	0.015	0.017
	(-0.69)	(0.83)	(0.98)
lninf	0.083*	-0.008	-0.004
	(1.71)	(-0.40)	(-0.19)

	Second Objective		Third Objective
	A	B	C
Dependent Variable	lnROA	lnP	lnP
DEA			0.164** (-2.22)
Adjusted R-squared	0.104	0.557	0.564
Durbin-Watson stat	2.271	0.792	0.779
S.E. of regression	0.486	0.221	0.223
Prob(J-statistic)	0.000		
Equilibrium Test			
E-Statistic	-0.293		
Wald Test (F-stat) for E=0	7.417		
Probability Value	0.067		
H- Statistics		0.587	0.586
Wald Test (F-stat) for H=1		20.783	15.776
Probability Value		0.000	0.000
Wald Test (F-stat) for H=0		3.280	6.025
Probability Value		0.071	0.074
Number of observations	580	580	581

NB: t-values in parentheses; *** 1% level of significance; ** 5% level of significance; * 10% level of significance.

The findings (Table 9, Column C) revealed that H-statistic remained relatively unchanged at 0.59, derived after summing of input factors lnw1, lnw2 and lnw3 coefficients. The coefficients of the input price of funds (lnw1) and coefficients input price of labour (lnw2) is again positive and significant at 1 percent. The coefficient of the input price of capital (lnw3) was again negative and not statistically significant. The coefficient of bank-specific variable lnnpl was negative but not significant, indicating deteriorating assets quality for banks lowers profits. On the other hand the coefficient of lnbsize was positive and significant at 10 percent. The coefficients of the macro variables logtbll and lninf were found to be insignificant. Managerial ability measured by efficiency score comes out largely as an important factor in promoting competition. The

efficiency score DEA is positive and significant at the 10 percent and 5 percent significance level, meaning increase in efficiency leads to higher banks profit. The Wald test (F-statistic) for H again shows that for the period 2001-2017, the banking sector in Kenya was characterized by monopolistic competition.

We undertook a comparative analysis of this study results with those obtained in the previous studies on Kenyan banking sector as presented in Table 10. This study finding is in concurrence with previous studies on Kenya that its banking sector is characterized by monopolistic competition. However, caution should be exercised when undertaking this comparison due to the fact these studies are different with regards to time period, methodology, data sources, explanatory variables etc. The comparison reveals our results H-statistics was the lowest among the most recent studies but falls somehow like the average H-statistic among all the presented previous studies. Furthermore, the table reveals variations amongst themselves.

Table 10: Comparison with Previous Studies on Kenya and African Countries/Regions Banking Industries.

Authors	Period	Dependent Variable	H-Statistics	No. Banks
Kenya				
Mwega (2011)	1998-2007	ln(IR/TA)	0.58	43
Sanya & Gaertner, (2012)	2002-2008	ln(IR/TA)	0.60	43
Claessens &Laeven (2003)	1994-2001	ln(TR/TA)	0.58	34
Ombongi & Long (2018)	1994-2016	ln(TR/TA)	0.72	38
Bikker, Shaffer, & Spierdijk, (2012).	1986-2004	ln(TR/TA)	0.63	49
Talam & Kiemo (2017)	2011-2016	ln(TR/TA)	0.63	39
African Countries & Regions				
Biekpe (2011) -Ghana	2000-2007	ln(TR/TA)	0.66	17
Mlambo & Ncube (2011)**	1999–2008	ln(IR/TA)	0.58	26
Southern Africa*	2000-2009	ln(TR/TA)	0.52	130
West Africa*	2000-2009	ln(TR/TA)	0.60	112
North Africa*	2000-2009	ln(TR/TA)	0.56	68
East Africa*	2000-2009	ln(TR/TA)	0.61	90

Note: IR = interest revenue, TR=Total Revenue, and TA=Total Assets, *see Fosu (2013), ** South Africa

Mwega (2011) study which covered the period 1998-2007 found lowest H-statistics among these studies at 0.58. On the other hand, a recent study by Ombongi & Long (2018) covering period 1994-2016 found the highest H-statistics at 0.72. Talam & Kiemo (2017) found H-statistics of 0.63 for the period covering 2011-2016. Similar results were also found by Bikker, Shaffer & Spierdijk (2002) cross country study for 1986-2016. In Africa context this study's results are relatively similar to those found in South Africa by Mlambo & Ncube (2011), Ghana by Biekpe (2011) and in different Africa Regions by Fosu (2013).

6.0 Conclusion and Policy Recommendations

In the paper, we evaluated the efficiency and competition dynamics of the Kenyan banking sector for the period 2001-2017. Efficiency is measured using the Data Envelopment Analysis methodology. Competition dynamics is assessed using the Panzar-Rosse methodology.

The study findings indicate on average, efficiency was on an upward trend and averaging at 69 percent. Overall inefficiency of commercial banks results more from pure technical inefficiency rather than from scale inefficiency as indicated by measures of 18 percent and 16 percent inefficiency respectively. This implies reforms, adoption of technology and changing business models have improved efficiency in the banking sector. The results also indicate that Kenyan banking sector is characterized by monopolistic competition as shown H-statistics of 0.59. This result confirms Kenyan banking industry is dominated by few large banks of which together account over 60 percent market share. Managerial ability measured by DEA efficiency score comes out largely as an important factor in promoting competition for the Kenyan banking sector.

The results reveal important policy implications. The DEA results indicate plenty of room for Kenyan banks to improve efficiency. This can be achieved by banks optimizing the scale of operations to shift towards increasing returns to scale, as well as gain from improving their pure technical efficiency by improving managerial skills and/or adoption of technology to deploy resources to their best optimal use. Further, bank consolidation over the years seems to favor efficiency and competition gains in the sector. The improvements in the industry ultimately allow banks to competitively price their products and create a market niche. Policymakers should continue adopting policies that promote greater banking sector efficiency and competition.

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Appendices

1.0 Research Methodology:

Equations 1 and 2

The fractional programming problem is then transformed into a linear programming model (CCR), as illustrated in equation 1.

Basic CCR formulation (Multiplier form)

$$Max\ w_0 = \sum_r u_r y_{rj0}$$ Subject to

$$\sum_r u_r x_{ij0} = 1$$

$$\sum_r u_r y_{rj} - \sum_r v_i x_{ij} \leq 0 \text{ for } j=1,2...n$$

$$u_r \geq 0 \text{ for } r=1,..... k$$

$$v_i \geq 0 \text{ for } i=1,..... m$$

The above linear programming problem aims to maximize the sum of weighted outputs of DMU0 subject to virtual inputs of DMU0 while maintaining the condition that the virtual outputs cannot be exceeded by virtual inputs of any DMUs (Farrell Model –output oriented). Both the fractional programming problem and the linear programming problem have the same objective function. CCR-inefficient firms are given an efficiency ratio w0 < 1. Efficiency indices of efficient firms are equal to '1'. Furthermore, there is at least one efficient unit that is used as the referencing unit for estimating relative weights for the inefficient units. Both linear programming problems outlined above can be used to directly estimate 'θ' which is derived from the basic CCR dual problem/ envelopment form. This form also derives the slack values of the problem.

The input oriented DEA targets to minimize inputs while adequately satisfying a given level of output (Cooper et al 2007; Zhu 2009).

$$Min\ B_0 = \theta$$ Subject to

i) $$\theta_0 x_{i0} - \Sigma_{j=1}^{n} \lambda_j x_{ij} \geq 0 \quad j = 1, 2 ....., n \qquad i = 1, 2 ....., m$$

$$\theta_0 x_{i0} - \Sigma_{j=1}^{n} \lambda_j x_{ij} \geq 0 \quad j = 1, 2 ....., n \qquad i = 1, 2 ....., m$$

ii) $w_0 = \sum_{j=1}^{m} \lambda_j \gamma_{rj} \geq y_{r0} \quad r = 1, 2 \ldots\ldots, s$

ii) $\lambda_j \geq 0$

iv) $\Sigma_{j=1}^{n} \lambda_j = 1$

2.0 Results and Empirical Findings

Table 1: Analysis of Banks at the Frontier by Bank Tiers

Year	Tier 1	Tier 2	Tier 3	Total
2001	0	4	0	4
2002	1	4	1	6
2003	1	3	0	4
2004	0	3	0	3
2005	0	3	1	4
2006	1	3	0	4
2007	1	7	0	8
2008	1	2	2	5
2009	0	3	1	4
2010	0	3	0	3
2011	0	3	2	5
2012	0	4	3	7
2013	1	3	4	8
2014	0	4	5	9
2015	1	3	3	7
2016	1	4	2	7
2017	1	4	2	7
Total banks	**8**	**12**	**17**	**37**

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