

BIG DATA ANALYTICS FINANCIAL CAPABILITIES AND COST EFFICIENCY OF COMMERCIAL BANKS IN KENYA

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ABSTRACT

This study examined the effect of Big Data Analytics Financial Data Management Capability and Big Data Analytics Financial Technological Capability on the cost efficiency of commercial banks in Kenya. The research was anchored on RBV Theory, Dynamic Capabilities Theory and Transaction Cost Theory. A cross-sectional research design was adopted covering all 38 licensed commercial banks in Kenya. Data were analyzed through descriptive statistics, Pearson correlation analysis, multiple linear regression and mediation analysis using Stata Version 18. The findings established that Big Data Analytics Financial Data Management Capability ($\beta = -5.1189$, $p = 0.010$), Big Data Analytics Financial Technological Capability ($\beta = -4.4983$, $p = 0.022$) had negative and statistically significant effects on the cost-to-income ratio, indicating enhanced cost efficiency. The study concludes that Big Data

Analytics financial capabilities enhance the cost efficiency of commercial banks both directly. The study recommends sustained investment in Big Data Analytics Financial Data Management Capability, greater investment priority for Financial Technological Capability, which was comparatively the least-developed capability. Central Bank of Kenya should incorporate Big Data Analytics financial capability and cost-efficiency considerations into supervisory guidance on banks' digital transformation and technology investments.

Key words: Big Data Analytics, Big Data Analytics Financial Capabilities, Big Data Analytics, Financial Technological Capability, Cost Efficiency, Financial Capabilities.

INTRODUCTION

Big Data Analytics (BDA) financial capabilities refer to a commercial bank's capability to mobilize and utilize financial data and analytics technologies to generate insights that support financial operations and decision-making. BDA capability goes beyond the possession of large volumes of data or analytics technologies because organizational value depends on the ability to combine and deploy the resources required for analytics. Sabharwal and Miah (2021) identify BDA capability as an organizational capacity for using analytics to support informed decision-making, while Huang, Song, Li, and Xie (2023) conceptualize it around the ability to leverage data management, technological resources and talent to generate business insights. In this study, BDA financial capabilities therefore refer to the ability of commercial banks in Kenya to combine financial data,

analytics technologies and organizational resources to support financial decision-making and improve cost efficiency.

BDA capabilities have been conceptualized through different combinations of data, technological, human and organizational resources. This variation reflects differences in the contexts and purposes for which analytics capabilities are examined. Huynh, Nippa, and Aichner (2023), in their systematic review of BDA capability literature, found considerable variation in the conceptualization and measurement of the construct, while Sabharwal and Miah (2021) similarly demonstrate that BDA capability extends across technological and organizational dimensions rather than representing a single resource. Guided by this multidimensional perspective, the present study operationalized BDA financial capabilities through two dimensions: BDA financial data management capability and BDA financial technological capability.

The cost-efficiency concern is evident across the commercial banking sector rather than being confined to a single category of banks. In 2024, the KBA (2025) reported cost-to-income ratios of 57.6% for large banks, 67.7% for medium-sized banks and 98.3% for small banks. The differences in magnitude demonstrate varying levels of cost efficiency, but the presence of material operating costs relative to income across all three categories makes cost management relevant throughout the sector. The CBK (2025) further identifies cybersecurity and compliance risks among the challenges accompanying increased adoption of technologies such as Big Data, Data Analytics, APIs and cloud computing. Consequently, technological transformation presents both opportunities for efficiency improvement and additional demands on financial and organizational resources.

The combination of widespread digitalization, growing BDA adoption and persistent variation in cost efficiency therefore makes Kenya's 38 commercial banks an appropriate context for the study. Rather than assuming that technology investment automatically produces efficiency gains, the sector provides an opportunity to examine whether the capabilities developed around those investments make a difference. Specifically, the study examined whether BDA financial data management and technological influence cost efficiency (CBK, 2025; KBA, 2025).

Statement of the Problem

Commercial banks are expected to operate cost efficiently because sustained financial intermediation requires them to control operating expenditure relative to the income generated from banking activities. This expectation has become more important as banks invest substantially in digital infrastructure and analytics technologies. The Central Bank of Kenya (CBK, 2025) documents extensive digital transformation within the banking sector, including adoption of Big Data and Data Analytics, while the Kenya Bankers Association (KBA, 2025) identifies cost management as an important consideration in an increasingly digital banking environment. Ideally, these investments should strengthen information processing, automate financial activities that enable banks to use resources more efficiently.

Despite this technological progress, cost efficiency remains a significant concern among commercial banks in Kenya. Analysis of published annual reports and financial statements shows that the average cost-to-income ratio declined from 58.4% in 2021 to 56.7% in 2022, before deteriorating to 64.2% in 2023. Although it improved to 61.0% in 2024, the ratio rose further to 65.3% in 2025, the highest level during the period under review. The KBA (2025) independently reported the 64.2% and 61.0% sector ratios for 2023 and 2024, respectively. More importantly, cost pressures extend across the banking sector, with KBA (2025) reporting 2024 cost-to-income ratios of 57.6% for large banks, 67.7% for medium-sized banks and 98.3% for small banks. The persistence and variation of relatively high operating costs alongside continued technological investment therefore raise the question of whether banks possess the capabilities required to translate BDA resources into improved cost efficiency.

Existing empirical evidence does not adequately resolve this problem. Aziz, et al., (2023) established the relevance of BDA capabilities to operational and market performance in Malaysian banking, while Mwemezi and Mandari (2024) examined technological, organizational and environmental factors influencing BDA adoption among Tanzanian banks. However, these studies did not explain whether distinct BDA financial data management, technological and organizational capabilities translate into cost efficiency measured by the cost-to-income ratio. Other evidence has concentrated on particular technologies or broader performance outcomes rather than the specific cost-efficiency consequence of BDA capabilities. The literature therefore leaves a conceptual and contextual gap regarding whether the capabilities surrounding BDA, rather than technological adoption itself, explain differences in cost efficiency among commercial banks in Kenya. This study addressed these gaps by determining the effect of big data analytics financial capabilities on the cost efficiency of commercial banks in Kenya.

General Objective

The research general objective was to determine the effect of big data analytics financial capabilities on the cost efficiency of commercial banks in Kenya.

Specific Objectives

The research specific objectives were to:

- i. To determine the effect of BDA financial data management capabilities on the cost efficiency of banks in Kenya.
- ii. To evaluate the effect of BDA financial technological capabilities on cost efficiency of commercial banks in Kenya.

Research Hypotheses

The study sought to test the following research hypotheses;

H01: BDA financial data management capabilities have no statistically significant effect on the cost efficiency of commercial banks in Kenya

H02: BDA financial technological capabilities have no statistically significant effect on the cost efficiency of commercial banks in Kenya

THEORETICAL REVIEW

This study was guided by the following theories;

Resource-Based View Theory

Barney (1991) hypothesized the RBV Theory to explain that internal organizational resources can be the basis for sustained competitive edge. This hypothesis suggests firms may vary in the resources they hold, and these disparities might lead to variances in organizational achievement (Barney, 1991; Peteraf, 1993). Especially when properly utilized, resources that are valuable, rare, inimitable and non-substitutable can give the organization a sustainable competitive advantage. The theory thus focuses on the value of internal resources (acquisition, development, integration and utilization). The theory provides a basis for expecting banks with stronger BDA financial data management capabilities to extract greater operational value from their financial data and ultimately improve cost efficiency.

Dynamic Capabilities Theory

This theory was formulated by Teece, Pisano, and Shuen (1997) to comprehend how an organization assimilates, develops, and reorganizes its internal and external capabilities to adjust to the evolving business climate. The theory contrasts with the other perspective, which focuses on the possession of valuable resources, and states that the capacity to continuously adapt and redeploy these resources is the source of sustained performance in dynamic environments. Teece (2018) also conceptualized dynamic capabilities as the capability to sense opportunities and threats, seize emerging opportunities, and to transform competencies and resources. Commercial banks are constantly facing evolving technological landscapes and are continuously building, combining, upgrading and reconfiguring analytics infrastructure and digital technologies to drive financial operations. The theory therefore provides a basis for expecting stronger BDA financial technological capability to enable banks to deploy analytics technologies more effectively and ultimately contribute to improved cost efficiency.

Transaction Cost Theory

This Theory emerged from Coase's (1937) development of a theory about the purpose of the firm and was further elaborated by Williamson (1981, 1985) in an attempt to explain how organisations choose governance structures that minimize the costs of economic transactions. The theory acknowledges that costs are incurred in information search, negotiation, coordination, monitoring, contracting and agreement enforcement during transactions. Organizations thus look for

governance structures and operational arrangements that reduce these costs and enable efficient economic activity. BDA financial capabilities can reduce information-processing, coordination, monitoring, and operational costs by improving financial data availability, facilitating analytics-driven decisions, and supporting technology-enabled financial processes. Accordingly, stronger BDA financial capabilities are expected to contribute to lower operating costs relative to operating income, reflected in a lower cost-to-income ratio among Kenyan commercial banks.

Empirical Review

Mwemezi and Mandari (2024) researched Big Data Analytics adoption in the Tanzanian banking industry utilizing the Technology–Organization–Environment framework. Three hundred and twenty-two valid responses were received from the bank managers, and Partial Least Squares Structural Equation Modelling was applied in the study. The findings established that technological and organizational factors, including top-management support and financial resources, were important in BDA adoption, while perceived risk affected adoption relationships. However, the study concentrated on antecedents of BDA adoption rather than the post-adoption efficiency outcomes of BDA capabilities. It also failed to showcase an ability to separate financial data management out and study cost efficiency based on the cost-to-income ratio. The conceptual and measurement gaps were bridged in the current research by investigating the impact of BDA financial data management capability on cost efficiency of Commercial Banks in Kenya.

Kyambade, Kagere, Namatovu, Ssentumbwe, Tushabe, and Oyella (2024) examined technological innovation, risk-management practices and financial performance among commercial banks in Uganda. The study used a quantitative cross-sectional design and found that technological innovation and risk-management practices were positively related to financial performance, with risk-management practices serving as a mediator. However, technological innovation was conceptualized broadly rather than specifically as BDA financial data management capability, while financial performance rather than cost efficiency was examined as the outcome. These constituted conceptual, measurement and geographical gaps that the present study addressed by focusing on BDA financial data management capability and cost efficiency among commercial banks in Kenya.

Adeyemo, Atolagbe, Aladejebi, Akinyede, and Afolabi (2024) examined technical efficiency in Nigerian banks when applying AI technologies. The study found that AI-integrated financial technologies led to a decrease in operational costs, enhanced customer service efficiency, and improvements in technical efficiency in banks, using Data Envelopment Analysis. However, the study focused on AI-driven FinTech applications rather than BDA financial technological capability and measured technical efficiency rather than cost efficiency using the cost-to-income ratio. This conceptual and measurement gap was overcome in the present study by focusing specifically on the measurement of financial technological capability and cost efficiency for BDA.

Getugi, Osoro and Kihara (2023) used secondary data from Tier I and Tier II commercial banks in Kenya to study the impact of online banking on commercial banks' technical efficiency in Kenya. The study employed causal-comparative design and concluded that online banking significantly improved the technical efficiency. It was not, however, a technology to deploy BDA in financial operations, but one of the specific digital technology delivery methods. In addition, the study focused on technical not cost efficiency and didn't account for financial innovation as an intervening variable. These were conceptual gaps, measurement gaps and mediation gaps that were targeted in the present study, which examined financial technological capability of BDA and cost efficiency of BDA.

RESEARCH METHODOLOGY

The study adopted an explanatory research design to examine the effect of BDA financial capabilities on cost efficiency. Explanatory research can be used when the intent of the research is to ascertain the relationships between variables and explain how changes in one variable relate to changes in another variable (Babbie, 2020; Saunders, Lewis, & Thornhill, 2023). The study objectives and hypothesis were therefore consistent with the design as they stated the relationships between BDA financial data management capability, BDA financial technological capability and cost efficiency.

Target population was all 38 commercial banks regulated and in operation in Kenya as reported by the CBK (CBK, 2025). Commercial banks were used as the unit of analysis because this study aimed to make inferences about the financial capabilities and cost efficiency of BDA of commercial banks. The unit of observation was the officers having the responsibilities relevant to the study variables. The unit of analysis and unit of observation were distinguished to ensure that the data was gathered at the same level at which the study hypotheses were tested (Saunders, Lewis, & Thornhill, 2023; Babbie, 2020).

The research employed census sampling technique, whereby all the 38 commercial banks licensed in Kenya were included. The size of the banks was small and manageable to allow the entire population to be sampled, so a census was appropriate. Babbie (2020) notes that studying an entire population eliminates sampling error arising from the selection of only a subset of the population, while Saunders, Lewis, and Thornhill (2023) observe that a census may be appropriate where the population is accessible and manageable.

The research adopted both original and supplementary data. The fundamental data was gathered by a systematic questionnaire distributed to the chosen officials of the 38 commercial banks. Structured questionnaires facilitate standardized measurement across respondents and are particularly appropriate where constructs are operationalized into predefined indicators for quantitative analysis (Saunders, Lewis, & Thornhill, 2023; DeVellis & Thorpe, 2021).

Data collection was undertaken systematically to ensure completeness and consistency. Following approval by the University and authorization from the NACOSTI, introductory letters were submitted to the 38 commercial banks seeking permission to conduct the study.

The research utilized multiple linear regression and regression-based mediation analysis to examine the relationships among BDA financial capabilities and cost efficiency. Multiple regression was utilized to estimate the effects of BDA financial data management capability and BDA financial technological capability

Diagnostic tests were conducted before hypothesis testing to determine whether the assumptions underlying multiple linear regression were adequately satisfied.

Descriptive Analysis

This section presented the descriptive statistics of BDA financial data management capability, BDA financial technological capability and financial cost efficiency. The statistics included were number of observations, mean, standard deviation, minimum and maximum values. Both the questionnaire-based constructs were scaled on a 5-point scale and cost efficiency was measured by the CIR. After the scores of the respondents were aggregated, 38 commercial banks were used for the analysis. These results are tabulated below in Table 1.

Table 1 Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
BDA Financial Data Management Capability (FDMC)	38	3.6201	0.5031	2.8000	4.6667
BDA Financial Technological Capability (FTC)	38	3.3821	0.4934	2.6667	4.5333
Cost-to-Income Ratio (CIR)	38	65.3000	7.4797	47.8605	77.2044

Source: Research Data (2026).

The findings indicate that the mean financial data management scores for BDA were 3.6201 with a variation of 0.5031, ranging from a minimum of 2.8000 to a maximum of 4.6667 indicating that its capabilities in financial data utilization, data quality, secure data storage, systems integration and data governance were relatively well developed. This proved to be the bank's BDA financial capability profile with the highest level of maturity, with the observed range suggesting maturities vary between banks. The mean and variation of the financial technological capability of BDA was 3.3821 and 0.4934, respectively, having range scores of 2.6667 and 4.5333. The mean represents a medium level of analytics technologies, automation, infrastructure and interoperability development among the banks. Technological capability, however, had the lowest mean scores of all three BDA dimensions, indicating that it was the one with the highest potential for improvement in the current study.

This finding is imperative for the present study because sufficient variation in the mediator was found across the banks and thus it was considered for further mediation analysis in the descriptive

results. The mean CIR was 65.30% with a standard deviation of 7.4797, and the range of the CIR was 47.86% to 77.20%. As such, on an average, the commercial banks' operating expenses were about 65.30% of the operating income. The wide range of CIRs suggests that there are significant differences in cost-efficiency positions across the banks, as a lower CIR represents greater cost efficiency.

The descriptive results indicate that the banks were fairly strong in terms of the financial data management capability ($M = 3.6201$) and comparatively less strong in terms of technological capability ($M = 3.3821$). The findings thus reflect strengths of BDA already present as well as relative capability gaps and provide adequate variation in the mediator and the dependent variable for the subsequent inferential analysis.

Diagnostic Tests

Diagnostic tests were performed to determine if data met the assumptions of multiple linear regression before correlation and regression/mediation analyses were done. The results are summarised in the subsequent subsections

Normality Test

Table 2 Shapiro–Wilk Normality Test

Variable	Obs	W	z	Sig.
Regression Residuals	38	0.9416	1.671	0.0473

Source: Research Data (2026).

Table 2 show that the regression residuals recorded a Shapiro–Wilk statistic of 0.9416 and a significance value of 0.0473. Since the p-value was slightly below 0.05, the null hypothesis of normality was rejected, indicating a marginal departure from normality.

Further assessment of the standardized residuals, however, showed that none exceeded the ± 3 threshold, with the largest absolute standardized residual being 2.9378. The departure from normality was therefore not associated with an extreme outlier. Given the relatively small sample of 38 banks, the violation was acknowledged and should be taken into account in statistical inference. Accordingly, robust inference is appropriate for the subsequent regression analysis.

Multicollinearity Test

Table 3 Multicollinearity Test Results

Variable	Tolerance	VIF
BDA Financial Data Management Capability (FDMC)	0.6161	1.62
BDA Financial Technological Capability (FTC)	0.8608	1.16
Mean VIF	—	1.39

Source: Research Data (2026).

The VIF values ranged from 1.16 to 1.79, with a mean VIF of 1.39, while tolerance values ranged between 0.6161 and 0.8608. All VIF values were substantially below the threshold of 5 and the tolerance values were correspondingly high. Multicollinearity was therefore not a concern, and both BDA financial capability dimensions were retained in the subsequent regression analysis.

Table 4 Breusch–Pagan/Cook–Weisberg Test

Test	Chi-Square	df	Sig.
Breusch–Pagan/Cook–Weisberg	1.23	1	0.2682

Source: Research Data (2026).

The Breusch–Pagan/Cook–Weisberg test yielded a chi-square statistic of 1.23 and a significance value of 0.2682. Since the p-value exceeded 0.05, the null hypothesis of constant variance was not rejected. The residuals were therefore homoscedastic, indicating that heteroskedasticity was not evident in the estimated model.

Linearity Test

Table 5 Ramsey RESET Test Results

Test	F-Statistic	df	Sig.
Ramsey RESET	0.06	(3, 31)	0.9825

Source: Research Data (2026).

The Ramsey RESET test resulted in an F-statistic of 0.06 and the significance value of 0.9825. The p-value was significantly larger than the value of 0.05, so the null hypothesis stating that no nonlinear combinations of fitted values were omitted was not rejected. The result, therefore, gave no justification for omitting the functional form, and, therefore, for the retention of the specified linear regression model.

Correlation Analysis

Pearson correlation analysis was performed to examine the direction and strength of the relationships between BDA financial data management capability and BDA financial technological capability, BDA and cost efficiency among commercial banks in Kenya. Since cost efficiency was measured using the cost-to-income ratio (CIR), lower CIR values represented greater cost efficiency. Thus, negative correlations with CIR indicated associations with greater cost efficiency. The results are exhibited in Table 6.

Table 6 Pearson Correlation Matrix

Variable	CIR	FDMC	FTC	FOC	FI
CIR	1.0000				
FDMC	-0.6185***	1.0000			
FTC	-0.4987**	0.2229	1.0000		

Note: *p < 0.05; **p < 0.01; ***p < 0.001; N = 38.

Source: Research Data (2026).

The financial data management ability of BDA was adversely and significantly connected to CIR ($r = -0.6185$, $p < 0.001$). This signifies that the better financial data management skills were linked with an increase in cost effectiveness. This study is one of the first to offer more detailed evidence on the link between financial data management capability and cost efficiency measured by CIR. The results showed that BDA financial technological capability was moderately and adversely correlated with CIR ($r = -0.4987$, $p = 0.0014$), meaning that the more technologically capable of the financial provided, the more cost-efficient was the BDA. While these studies adopted various indicators of technology and efficiency, the results of these studies also reveal that there is a connection between technology capabilities and banking efficiency.

Hypothesis Testing

Summary of Hypothesis Testing Results

The results of the four hypotheses tested at the 5% level of significance are summarized in Table 7.

Table 7 Summary of Hypothesis Testing Results

Hypothesis	Relationship Tested	Coefficient (β)	Test Statistic	p-value	Decision	Conclusion
H ₀₁	BDA Financial Data Management Capability → Cost Efficiency	-5.1189	t = -2.72	0.010	Reject H ₀₁	Negative and statistically significant effect on CIR, implying improved cost efficiency
H ₀₂	BDA Financial Technological Capability → Cost Efficiency	-4.4983	t = -2.40	0.022	Reject H ₀₂	Negative and statistically significant effect on CIR, implying improved cost efficiency

Research Data (2026).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This section delineates the conclusions derived from the research's findings in alignment with the defined goals. The conclusions reflect what the established effects and mediating relationship imply for Big Data Analytics financial capabilities and the cost efficiency of commercial banks in Kenya. Firstly, the study established that BDA Financial Data Management Capability had a adverse and significant effect on the cost-to-income ratio and therefore enhanced cost efficiency. BDA Financial Data Management Capability was operationalized as a composite construct consisting of financial data utilization, financial data quality management, financial data storage, financial systems integration and financial data governance. Overall, the study findings suggested that the interrelated dimensions of financial data management can be strengthened to improve the

ability of commercial banks to reduce their operating expenses compared to their operating income. This implies that effective utilization and governance of quality financial data, supported by appropriate storage and integrated financial systems, collectively constitute an important data-management capability for achieving greater cost efficiency.

Secondly, BDA Financial Technological Capability had a adverse and significant impact on cost to income ratio and thus increased cost efficiency. The capability was evaluated as a composite—comprising financial analytics deployment, financial analytics integration, financial process automation, financial analytics infrastructure, and financial analytics interoperability. The study concludes that these technological dimensions, when developed collectively as a BDA financial technological capability, strengthen the capacity of commercial banks to undertake financial operations more efficiently. Thus, banks require not merely analytical technologies, but an integrated technological capability in which analytics are deployed and integrated into financial operations, supported by automation, adequate infrastructure, and interoperable systems.

Recommendations for Policy and Practice

The recommendations of the study are derived from the conclusions relating to the BDA financial capabilities on cost efficiency. They focus on investment priorities, capability development and policy actions through which commercial banks can enhance cost efficiency. Firstly, the study concluded that BDA Financial Data Management Capability enhances the cost efficiency of commercial banks. Commercial banks should therefore continue and further invest in this capability, specifically financial data utilization, financial data quality management, financial data storage, financial systems integration and financial data governance. Since Financial Data Management Capability was comparatively well developed among the banks studied, priority should be placed on deriving greater efficiency value from the existing capability. Bank management should therefore consider investments in these areas based on which impact these investments will have on operating expenditure and cost-to-income position.

The study concluded that BDA Financial Technological Capability enhances the cost efficiency of commercial banks. The descriptive findings also highlighted this as the less developed financial capability among the three, and this suggests that it is an important target for further investments in the BDA. Commercial banks should therefore direct greater BDA investment towards identified gaps in financial analytics deployment, financial analytics integration, financial process automation, financial analytics infrastructure and interoperability. Bank Boards and investment committees should have a robust requirement on technologies to define desired outcomes of operation in terms of efficiency and to then assess if such efficiencies are met. This would direct additional BDA investment towards the relative capability gap identified by the study while maintaining a clear cost-efficiency objective.

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