

Technology Adoption, Governance Practices and Operational Performance of Dairy Cooperatives in Kiambu County, Kenya

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Abstract: Technology adoption and effective governance are increasingly important organizational capabilities for improving the efficiency, accountability, and competitiveness of agricultural cooperatives. This study examined the relationship between technology adoption, governance practices, and the operational performance of dairy cooperative societies in Kiambu County, Kenya. A descriptive cross-sectional research design was employed, covering 19 dairy cooperative societies. Data were collected from managers, board members, and cooperative-member employees using structured questionnaires. Of the 78 targeted respondents, 69 participated, yielding an 88.46% response rate. Primary survey data were complemented by 2024 milk production and milk payment data obtained from the Kenya Dairy Board. Technology adoption was assessed using indicators including electronic payment systems, dairy management technologies, computerized records, and real-time data capture, while governance practices were assessed through board structure, accountability, leader-member communication, and member participation. Operational performance was measured using an Operational Performance Index based on annual milk production volume and average milk payment per litre. Pearson correlation and multiple linear regression analyses were conducted, with aggregation strategies included as a control variable. The regression model was statistically significant and explained 85.7% of the variation in log operational performance ($R^2 = 0.857$, $F(3,15) = 29.874$, $p < 0.001$). Technology adoption was positively and significantly associated with operational performance ($\beta = 1.070$, $p = 0.042$), while governance practices also showed a positive and significant association ($\beta = 0.381$, $p = 0.012$). Consistent with these results, technology adoption had a strong positive correlation with operational performance ($r = 0.797$, $p < 0.01$), while governance practices had a substantial positive correlation ($r = 0.649$, $p < 0.01$). Qualitative findings indicated that digital payments, computerized records, digital communication, and real-time data systems improved record accuracy, payment efficiency, information flow, monitoring, coordination, and decision-making. Effective governance strengthened accountability, board oversight, transparency, member participation, and resource management. The findings further suggest that technology and governance operate as complementary organizational capabilities, with their benefits depending on adequate infrastructure, financial resources, staff competencies, effective leadership, and member engagement. The study recommends an integrated approach combining affordable and scalable digital technologies with governance capacity building, transparent communication, effective board oversight, member participation, and continuous staff development. Given the cross-sectional design and the small number of cooperative-level observations, the findings demonstrate significant associations rather than definitive causal effects.

Keywords: Technology adoption; Governance practices; Dairy cooperatives; Operational performance; Digitalization; Aggregation strategies; Kenya.

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Introduction

Agricultural cooperatives play a central role in the commercialization of smallholder agriculture, particularly in the dairy sector, by facilitating collective milk marketing, access to agricultural services, payment systems, and participation in value chains. The effectiveness of these cooperatives increasingly depends on their capacity to adopt and effectively utilize appropriate technologies and maintain sound governance practices. Digital technologies, including electronic payment systems, dairy management platforms, computerized records, and real-time data collection, can enhance operational efficiency, improve payment

transparency, strengthen record management, and facilitate access to timely information. However, the realization of these benefits depends not only on technology adoption but also on the capacity of cooperatives to manage and utilize technological systems effectively. Similarly, strong governance, characterized by effective boards, member participation, leadership accountability, transparent communication, and sound resource management, is essential for effective strategic decision-making, organizational coordination, transparency, and the maintenance of member trust.

Evidence from Kenya and other African countries increasingly demonstrates the contribution of digital technologies and sound governance practices to cooperative effectiveness and performance. Nevertheless, despite growing recognition of technology and governance as important drivers of cooperative performance, limited empirical research has examined their combined influence on the operational performance of dairy cooperative societies in Kenya. This gap is particularly significant in Kiambu County, where dairy cooperatives play an important role in supporting smallholder farmers through milk aggregation and marketing, provision of services, payment facilitation, and coordination within dairy value chains. Against this background, the study examined the influence of technology adoption and governance practices on the operational performance of dairy cooperative societies in Kiambu County, Kenya.

Specifically, the study sought to determine the effect of technology adoption on the operational performance of dairy cooperative societies in Kiambu County and to assess the effect of governance practices on their operational performance. To achieve these objectives, the study tested two null hypotheses: **H₀₁**, that technology adoption has no significant effect on the operational performance of dairy cooperative societies in Kiambu County; and **H₀₂**, that governance practices have no significant effect on the operational performance of dairy cooperative societies in Kiambu County.

Literature Review

Technology Adoption and Operational Performance

Technology adoption refers to the acceptance, use and integration of relevant technologies into routine dairy cooperative operations, including milk collection and quality testing, payments, communication, record management, financial management and marketing. Evidence from Kenya shows a positive relationship between technology adoption and cooperative performance; for example, Githinji et al. (2022) found a significant association with cooperative development in Kiambu County ($r = .646, p < .001$). Adoption is influenced by complementary economic, institutional and farmer-level factors, including education, herd size, milk yield, credit access, training, record-keeping, income, cooperative membership, access to information, markets and veterinary services (Okello et al., 2021; Muriuki et al., 2022; Mutuma et al., 2023).

Technology adoption can enhance cooperative performance by increasing productivity, reducing transaction costs, improving information accuracy and communication, and strengthening service delivery. Dairy technologies are often adopted as complementary practices, with income, education, extension and credit influencing their uptake (Kiriti et al., 2024), while improved feed technologies can increase dairy income and milk supply (Ngeno, 2024; KDB, 2024). However, technology ownership alone does not ensure improved performance, as affordability, inadequate skills, weak infrastructure and limited extension support can constrain effective use. In addition, the study by Mutuma et al. (2023) and Anno & Ameripus (2022) conceptualized the significance of technology adoption as the effective integration and utilization of relevant technologies in cooperative operations, supported by appropriate training, finance, information and organizational capacity.

Governance Practices and Cooperatives

Governance refers to the structures, rules and processes through which an organization is directed, controlled and held accountable. In dairy cooperatives, it includes board oversight, financial accountability, transparency, internal controls, regulatory compliance, auditing, strategic decision-making and member participation. Kenyan studies associate sound governance with improved cooperative performance. Mwajedi et al. (2022), Ngoda and Kising'u (2024), and Maingi and Kobuthi (2024) found that board composition, independence, accountability, audit committees and financial controls positively influenced performance. Njeru et al. (2026) similarly found that strategic controls significantly improved agricultural cooperative performance, although effects varied by cooperative size.

According to Maingi and Kobuthi (2024) and Anno (2026) show that effective governance reduces agency problems and information asymmetry through transparency, audits, internal controls, communication and member participation, thereby strengthening trust, accountability and operational efficiency. However, its effectiveness may depend on cooperative size, management capacity, resources and market conditions. Since much Kenyan evidence focuses on SACCOs and other cooperatives, and critical agricultural value chain development organizations.

Operational Performance of Cooperatives

Operational performance refers to an organization's efficiency and effectiveness in converting resources and activities into desired outcomes. In dairy cooperatives, it includes commercial, member-service and organizational outcomes, measured through milk collection volumes, productivity, operating costs, revenue or surplus, milk quality, member payment rates and service efficiency (Okello et al., 2021). Milk collection is particularly important because aggregation creates economies of scale in transportation, processing and marketing. Technology adoption can enhance productivity, reduce operational bottlenecks, improve quality testing, record management, market information and transaction processes, although its benefits depend on whether efficiency gains outweigh acquisition, maintenance and training costs. Studies link technology use with improved milk production, income and cooperative development in Kiambu County (Ngeno, 2024; Githinji et al., 2022).

Governance also influences operational performance by strengthening accountability, resource allocation, financial oversight and strategic control. Board accountability, audit committees and effective board structures have been positively associated with cooperative performance, while strategic controls can further enhance agricultural cooperative performance (Maingi & Kobuthi, 2024; Ngoda & Kising'u, 2024; Njeru et al., 2026). Thus, operational performance reflects the combined influence of technology, governance and market factors and can be comprehensively assessed using indicators such as milk collection, productivity, operating costs, revenue, quality, payment rates and service efficiency (Kamau, Njiru & Wanjiru, 2023).

Theoretical Linkages between Technology Adoption, Governance and Operational Performance

The relationship between technology adoption, governance and operational performance is supported by several complementary theories. Diffusion of Innovations Theory explains

technology adoption through relative advantage, compatibility and ease of use, while the Resource-Based View emphasizes how technology, information systems, employee skills and organizational routines can become valuable capabilities when effectively integrated. Agency Theory links governance to performance by highlighting conflicts between members, boards and managers, which can be reduced through effective oversight, auditing, transparency, participation and accountability. Transaction Cost Economics further shows that technology and governance can lower information, coordination, monitoring, quality-control, payment and contracting costs (Njiru, Gachanja, & Wanjiku, 2020; Mwebia, 2024).

Collectively, these theories suggest that technology and governance are interdependent determinants of performance. According to Mugambi, Kinoti, & Ombaka (2022), Technology strengthens information, coordination and service delivery, while governance ensures that these capabilities are properly directed, monitored and sustained. Their integration can therefore enhance operational performance more effectively than either factor alone.

Empirical Gap on Dairy Cooperatives Development

The reviewed literature indicates that technology adoption and governance influence organizational performance, but significant gaps remain. Kenyan studies on technology adoption have largely focused on individual dairy farmers and household outcomes (Okello et al., 2021; Mutuma et al., 2023; Kirimi et al., 2024; Ngeno, 2024), with limited evidence on cooperative-level performance. Although Githinji et al. (2022) examined technology adoption in dairy cooperatives in Kiambu County, the focus was on cooperative development rather than broader operational performance.

Governance studies have also mainly examined SACCOs, whose contexts differ from dairy cooperatives. Furthermore, few studies have examined technology adoption and governance jointly, despite their complementary roles in information management, accountability, decision-making and operational control (Mwajedi et al., 2022; Ngoda & Kising'u, 2024; Maingi & Kobuthi, 2024).

Theoretical Framework

The study draws on the resource-based view and agency theory. The resource-based view proposes that organizations can achieve superior performance by developing valuable and difficult-to-replicate resources and capabilities. Technology infrastructure, digital competencies, management information systems, and organizational knowledge can therefore function as strategic capabilities.

Agency theory, associated with Jensen and Meckling (1976), provides a useful explanation for the governance dimension. In cooperatives, members delegate aspects of organizational management to boards and managers. Governance mechanisms can reduce information asymmetry and agency problems by strengthening oversight, accountability, communication, and member participation. The combination of these theoretical perspectives suggests that technology can improve the efficiency of information and transactions, while governance can ensure that organizational resources are deployed responsibly and in members' interests.

Methodology

Research Design

The study employed a descriptive cross-sectional research design, with 19 dairy cooperative societies in Kiambu County serving as the units of study and analysis. The study population comprised individuals directly involved in the operations and management of the dairy cooperatives, particularly cooperative managers, board members, and employees who were also cooperative members, who served as key informants.

Sampling and Data Collection

A stratified purposive sampling procedure was employed to select 78 key informants, ensuring representation across the three key stakeholder categories. Of these, 69 respondents participated in the study, yielding an overall response rate of 88.46%. Data were collected using structured questionnaires administered through self-completion and Google Forms. The questionnaire comprised five-point Likert-scale items designed to capture respondents' perceptions of the study variables.

Prior to the main data collection, the research instrument was pretested in dairy cooperatives that were not included in the study. The pretest involved 15 respondents drawn from the same categories as the study participants. The pretesting process helped assess the clarity, relevance, consistency, and suitability of the research instrument, resulting in appropriate adjustments to enhance its credibility and overall quality before the final administration.

Measures

Technology adoption was measured through indicators including electronic payment systems, dairy management systems, and real-time data capture. The technology adoption scale had a Cronbach's alpha of 0.764, indicating acceptable internal consistency. Governance practices were measured through board structure, accountability, leader-member communication, and member participation. The governance scale recorded a Cronbach's alpha of 0.803, indicating high internal consistency.

Operational performance was measured through an Operational Performance Index calculated as: $OPI = \text{Total annual milk production} \times \text{Average milk payment per litre}$. The natural logarithm of OPI was used as the dependent variable in regression analysis. The model was specified as: $\log OPI = \beta_0 + \beta_1 AS + \beta_2 TA + \beta_3 GP + \epsilon$, where TA represents technology adoption and GP represents governance practices. Aggregation strategies were included as a control predictor so that the independent effects of technology and governance could be estimated.

Results

Quantitative Results

Descriptive Statistics

The descriptive statistics provide an overview of respondents' perceptions of technology adoption, governance practices, and operational performance across the dairy cooperative societies studied. Technology adoption recorded a relatively high mean score of 3.600 (SD = 0.408), indicating generally positive perceptions and relatively consistent adoption of technologies such as digital communication, information management, milk collection and recording systems, and payment systems. In

contrast, governance practices recorded a lower mean of 2.807 (SD = 1.077), suggesting fewer positive perceptions and substantial variation across cooperatives. This variability may reflect differences in accountability, transparency, member participation, leadership effectiveness, policy adherence, and oversight, with some cooperatives demonstrating stronger governance systems than others.

The dependent variable, log Operational Performance Index (logOPI), recorded a mean of 4.616 and a standard deviation of 1.298, indicating meaningful differences in operational performance among the sampled cooperatives. This variation provides sufficient basis for examining whether differences in technology adoption, governance practices, and other organizational strategies are associated with operational performance. Overall, the findings show that technology adoption was the most positively perceived construct, while governance practices exhibited the greatest variability. The variation in operational performance further suggests that differences in organizational practices may help explain why some dairy cooperatives achieve better operational outcomes than others.

Correlation Results

Pearson correlation analysis was conducted to establish the direction and strength of the relationships among aggregation strategies, technology adoption, governance practices, and operational performance. The results show generally positive associations, although their strength and statistical significance varied. Technology adoption had a strong and statistically significant positive correlation with operational performance ($r = 0.797$, $p < 0.01$), indicating that cooperatives with higher technology adoption tended to report better operational

performance. Technology may enhance performance through improved information exchange, milk collection and recording, coordination, market access, cost reduction, and decision-making. Governance practices also had a positive and statistically significant correlation with operational performance ($r = 0.649$, $p < 0.01$), suggesting that stronger governance was associated with better performance through improved accountability, managerial oversight, transparency, compliance, and alignment with members' interests. These correlations indicate association rather than causation.

A strong positive and statistically significant relationship was observed between technology adoption and aggregation strategies ($r = 0.761$, $p < 0.01$), suggesting that cooperatives with stronger technological capabilities were more likely to have effective aggregation strategies. Technology can support aggregation by improving coordination of milk collection, communication, record-keeping, volume monitoring, delivery tracking, and transactions with buyers. In contrast, the relationship between governance practices and technology adoption was positive but statistically insignificant ($r = 0.373$, $p = 0.115$), indicating insufficient evidence of a significant relationship in the study population. This may suggest that technology adoption is influenced by other factors, including financial resources, infrastructure, managerial capacity, member demand, technical support, and external partnerships. Overall, technology adoption had the strongest bivariate association with operational performance, followed by governance practices, while its strong relationship with aggregation strategies provides further justification for examining the explanatory variables jointly through multiple regression analysis.

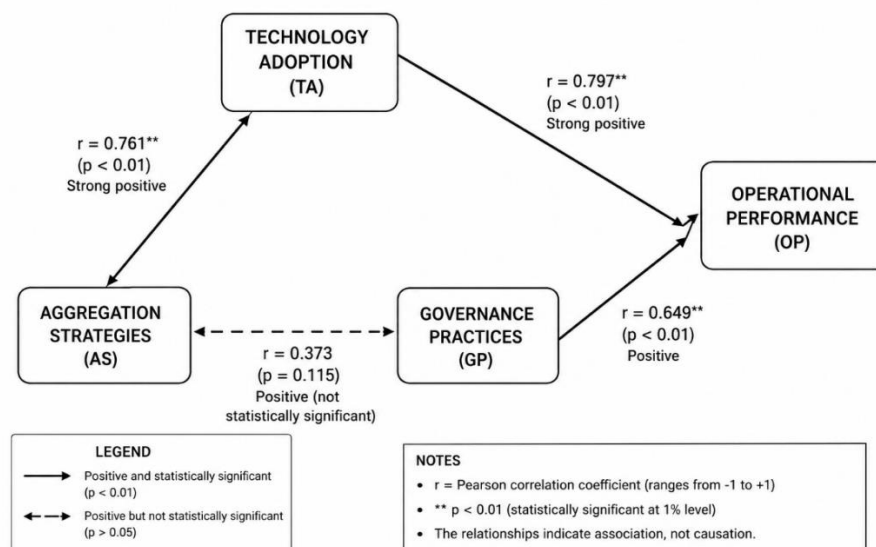


Figure 1: Summary of correlation results. Source: Researcher made.

Regression Results

A multiple linear regression model was estimated to determine whether aggregation strategies, technology adoption, and governance practices were jointly associated with operational performance while controlling for the effects of the other explanatory variables. Operational performance was measured using the logarithm of the Operational Performance Index

(logOPI). The overall regression model was statistically significant, $R^2 = 0.857$, $F(3,15) = 29.874$, $p < 0.001$. The R^2 value indicates that 85.7% of the observed variation in log operational performance was explained jointly by aggregation strategies, technology adoption, and governance practices. The remaining 14.3% represents variation attributable to other factors not included in the model, random variation, and measurement-related influences.

The statistically significant F-test indicates that the explanatory variables, when considered jointly, provided a significantly better explanation of operational performance than a model without these predictors. Thus, the findings provide strong evidence of an overall relationship between the three organizational factors and operational performance. Given the relatively small number of observations, however, the high explanatory power should be interpreted with appropriate caution because estimates from small samples can be sensitive to individual observations.

Technology Adoption

Technology adoption had a positive and statistically significant effect on operational performance ($\beta = 1.070$, $SE = 0.480$, $t = 2.23$, $p = 0.042$). The positive coefficient indicates that, holding aggregation strategies and governance practices constant, higher technology adoption was associated with higher operational performance. Since the p-value of 0.042 is below the 5% significance level, the null hypothesis that technology adoption has no significant effect on operational performance was rejected. Because the dependent variable is expressed in logarithmic form, the coefficient implies that a one-unit increase in the technology adoption score is associated with an estimated 191.6% increase in expected operational performance ($e^{1.070} - 1 \approx 1.916$), ceteris paribus.

This represents a substantial estimated association and suggests that technology adoption is an important contributor to differences in cooperative operational performance. However, the magnitude should be interpreted cautiously because a one-unit increase may represent a relatively large change in the technology adoption construct, and the analysis is based on only 19 cooperative-level observations. Thus, the coefficient should be viewed as a conditional association rather than definitive evidence that technology adoption alone causes a 191.6% increase in operational performance. Nevertheless, the finding supports the importance of technologies that improve information management, communication, milk collection, record keeping, payment systems,

coordination, and market linkages in enhancing the efficiency and responsiveness of dairy cooperative operations.

Governance Practices

Governance practices also had a positive and statistically significant coefficient ($\beta = 0.381$, $SE = 0.133$, $t = 2.87$, $p = 0.012$). The positive coefficient indicates that stronger governance practices were associated with higher levels of operational performance after controlling for aggregation strategies and technology adoption.

The p-value of 0.012 is below the 5% significance threshold. Consequently, the null hypothesis that governance practices have no statistically significant effect on operational performance was rejected. The result demonstrates that governance practices made a statistically significant independent contribution to the explanation of operational performance. The logarithmic specification allows the coefficient to be converted into an approximate percentage change in expected OPI. The transformation is: $e^{0.381} - 1 \approx 0.464$, which corresponds to an estimated 46.4% increase in expected OPI for a one-unit increase in governance practices, holding aggregation strategies and technology adoption constant.

The finding highlights the importance of institutional and managerial arrangements in determining cooperative operational outcomes. Effective governance can facilitate accountability, transparency, oversight, member participation, resource management, and strategic decision-making. Strong governance may also enhance the implementation of aggregation and technology-related investments by ensuring that organizational resources are properly managed and that operational decisions are aligned with cooperative objectives.

The statistically significant governance coefficient is particularly relevant given the relatively lower mean governance score and greater variation reported in the descriptive statistics. The results suggest that strengthening governance could represent an important avenue for improving operational performance across cooperatives with comparatively weaker governance systems.

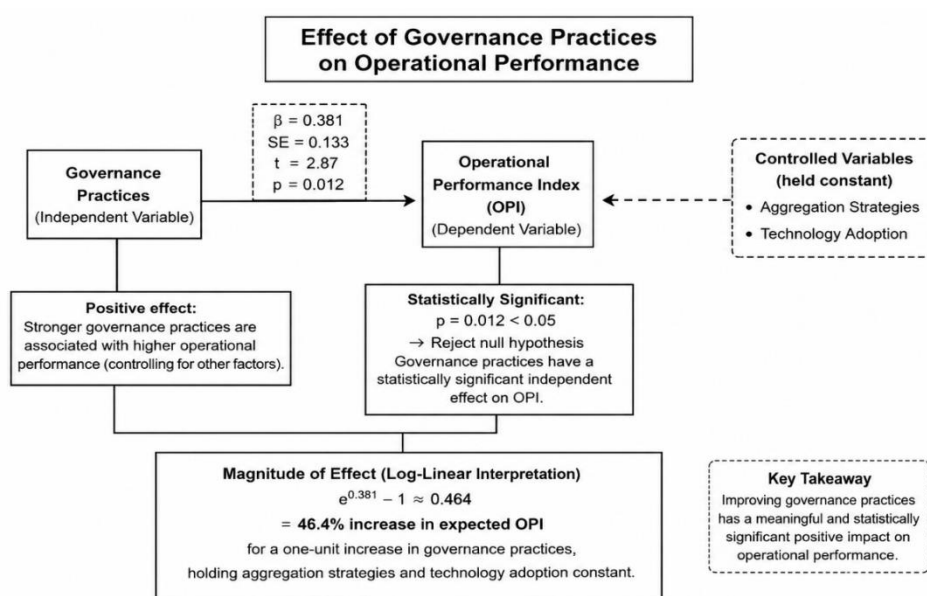


Figure 2: Summary of governance practices. Source: Researcher made.

Model Diagnostics

Diagnostic tests were conducted to assess whether the regression model met the principal assumptions required for reliable estimation and interpretation. The results indicated no major violations. The mean Variance Inflation Factor (VIF) was 2.084, with all individual VIF values below 5, suggesting that multicollinearity was not a serious concern despite the strong bivariate correlation between technology adoption and aggregation strategies ($r = 0.761$). The Breusch-Pagan/Cook-Weisberg test produced $p = 0.1766$, which is above the 5% significance level, indicating no significant evidence of heteroscedasticity and supporting the assumption of constant error variance.

The Shapiro-Wilk test produced $p = 0.383$, providing insufficient evidence to reject the assumption of normally distributed residuals. In addition, visual inspection of the residual-versus-fitted-value plot showed no obvious systematic pattern or pronounced curvature, suggesting that serious non-linearity was not present. Overall, the diagnostic results indicate that the model did not exhibit serious problems relating to multicollinearity, heteroscedasticity, residual normality, or non-linearity. The regression model was therefore considered statistically adequate for interpreting the reported coefficients, subject to the limitation imposed by the small sample size.

Qualitative Results

Technology Adoption and Operational Efficiency

The qualitative findings showed that technology adoption was widely perceived as an important contributor to operational performance. Electronic payment systems, computerized records, digital communication, milk collection technologies, and real-time data capture improved efficiency, accuracy, transparency, and service delivery. These technologies enabled faster processing of milk records and payments, easier retrieval of member information, improved monitoring of deliveries, and reduced errors and delays associated with manual systems. Real-time data also supported better planning and decision-making on milk collection, marketing, farmer services, and financial management. However, respondents noted that effectiveness depended on reliable infrastructure, adequate financing, staff capacity, and user training.

Governance, Leadership and Member Participation

Respondents identified accountability, effective board oversight, transparent management, clear leadership roles, financial reporting, auditing, policy compliance, and separation of board and management responsibilities as key governance factors influencing performance. Competent and active boards were perceived to provide better strategic direction and resource oversight, while weak governance could result in delayed decisions, poor resource utilization, conflicts, and declining member confidence. Member participation, regular meetings, communication, feedback mechanisms, cooperative education, board training, and succession planning were also considered important for strengthening ownership, trust, and accountability.

Complementarity of Technology and Governance

The findings indicated that technology adoption and governance practices function as complementary capabilities in improving operational performance. Digital systems provide timely and accurate information, but effective leadership is required to

ensure that such information is appropriately interpreted, protected, and used in decision-making. Similarly, electronic payments and computerized records enhance transparency when supported by accountable and responsive leadership. Overall, improved cooperative performance requires a combination of appropriate digital technologies, accountable governance, member participation, staff capacity, and transparent management systems.

Summary of Key Results

The quantitative findings indicate that organizational capabilities were positively associated with operational performance among the dairy cooperative societies studied. Technology adoption had the strongest bivariate relationship with operational performance ($r = 0.797$, $p < 0.01$), followed by governance practices ($r = 0.649$, $p < 0.01$). Technology adoption was also strongly associated with aggregation strategies ($r = 0.761$, $p < 0.01$). Regression results further showed that aggregation strategies, technology adoption, and governance practices jointly explained 85.7% of the variation in log operational performance, with the overall model being statistically significant ($F(3,15) = 29.874$, $p < 0.001$). Technology adoption and governance practices each made significant positive contributions to operational performance, suggesting that performance is influenced by a combination of effective aggregation, technology adoption, and sound governance.

Despite the strong quantitative relationships, the findings should be interpreted cautiously because the analysis was based on only 19 cooperative-level observations and used a cross-sectional design. The small sample limits statistical power and generalizability, while the cross-sectional data establish associations rather than definitive causal relationships. The relatively large technology adoption coefficient should therefore be validated using larger samples and, where possible, longitudinal data. Nevertheless, the consistency between the correlation and regression results, supported by satisfactory diagnostic tests, provides empirical evidence that aggregation strategies, technology adoption, and governance practices are important organizational capabilities for explaining operational performance among dairy cooperative societies.

The qualitative findings indicate that technology adoption and effective governance are complementary capabilities that enhance the operational performance of dairy cooperatives in Kiambu County. Digital systems improved record accuracy, payment efficiency, communication, monitoring, and managerial decision-making, while effective governance ensured that these technological resources were properly managed and translated into better services and accountability. However, the benefits of technology were constrained by inadequate infrastructure, financial resources, and staff skills, while weak governance could undermine resource utilization and member confidence. Overall, the findings suggest that improved cooperative performance requires an integrated approach combining appropriate digital technologies with accountable leadership, effective board oversight, member participation, staff capacity development, and transparent management systems.

Discussion

Technology Adoption and Operational Performance of Dairy Cooperatives

The findings show that technology adoption is significantly associated with operational performance of dairy cooperatives in Kiambu County. Technology adoption had a strong positive correlation with operational performance ($r = 0.797$, $p < 0.01$) and a significant positive regression effect after controlling for aggregation strategies and governance ($\beta = 1.070$, $p = 0.042$). Qualitative evidence attributed these gains to electronic payments, computerized records, real-time data capture, digital communication, and dairy management technologies, which improve efficiency, transparency, information access, coordination, and decision-making. The findings support the Resource-Based View (Wernerfelt, 1984; Barney, 1991) and Diffusion of Innovations Theory (Rogers, 2003), suggesting that technology creates value when effectively integrated into routine operations. They also reinforce previous evidence on digital technologies and dairy cooperative performance (Njiru et al., 2020; Mugambi et al., 2022).

However, the benefits of technology adoption are constrained by poor internet connectivity, equipment failures, limited technical skills, inadequate training, and financial constraints. Thus, technology alone does not guarantee improved performance; cooperatives must have the capacity to acquire, maintain, use, and adapt technological systems effectively. These findings are consistent with Tavakol and Dennick (2011) and Wu and Leung (2017), who emphasize cost and complementary institutional conditions as important to technology adoption. The regression results should nevertheless be interpreted cautiously because the analysis involved only 19 cooperative-level observations, limiting the generalizability of the estimated effect.

Governance Practices and Operational Performance

Governance practices had a positive and statistically significant relationship with operational performance. Governance recorded a moderate mean score of 2.807 and significant correlation with operational performance ($r = 0.649$, $p < 0.01$), while also making an independent contribution in the regression model ($\beta = 0.381$, $p = 0.012$). The findings show that effective board oversight, accountability, transparency, auditing, and clear roles between boards and management enhance resource utilization and operational efficiency. This supports Agency Theory and previous evidence linking good governance to cooperative sustainability and institutional performance.

Qualitative findings showed that active boards, regular financial reporting, effective communication, member participation, and leadership accountability improved cooperative operations and member trust. Conversely, poor communication contributed to mistrust, conflict, and resistance to decisions. The findings therefore suggest that governance is most effective when it combines accountability and transparency with flexibility, enabling cooperatives to respond to changing markets, technology, milk supply, and member needs.

Technology Adoption, Governance and Organizational Complementarity

The findings suggest that technology adoption and governance are complementary organizational capabilities.

Although their relationship was positive but not statistically significant ($r = 0.373$, $p = 0.115$), both independently had significant positive relationships with operational performance. Qualitative evidence indicates that technology generates timely and accurate information, while effective governance ensures its responsible use through monitoring, accountability, and member responsiveness. This supports the Resource-Based View and Agency Theory, which emphasize technology and organizational knowledge as valuable resources and governance as the mechanism for their effective deployment.

The findings also support Transaction Cost Economics, as technology can reduce information, coordination, monitoring, and transaction costs, while governance strengthens accountability and organizational coordination (Williamson, 1979, 1989). The strong relationship between technology adoption and aggregation strategies ($r = 0.761$, $p < 0.01$) further highlights their interdependence, with digital systems supporting milk-volume monitoring, collection coordination, record-keeping, and communication. Overall, technology, governance, and aggregation should be integrated rather than treated as stand-alone interventions.

Integration of Quantitative and Qualitative Findings

The quantitative and qualitative findings converge in showing that technology adoption and governance practices are important contributors to dairy cooperative operational performance. Technology adoption had the strongest bivariate relationship with performance ($r = 0.797$), while governance also showed a substantial positive relationship ($r = 0.649$). Both remained statistically significant in the regression model, with technology adoption ($\beta = 1.070$, $p = 0.042$) and governance practices ($\beta = 0.381$, $p = 0.012$). These results were consistent with respondents' emphasis on technology, accountability, leadership, communication, member participation, and information management. Technology also recorded a higher mean (3.600; SD = 0.408) than governance (mean = 2.807; SD = 1.077), suggesting more consistent technological practices across cooperatives, whereas governance arrangements varied considerably.

The findings further indicate that technology and governance are complementary capabilities rather than substitutes. Effective digital systems require strong leadership, accountability, and information use, while good governance depends on adequate systems for data management, payments, milk collection, and monitoring. Together with aggregation strategies, the three factors explained 85.7% of the variation in log operational performance ($R^2 = 0.857$, $p < 0.001$). Although the cross-sectional design and small number of cooperative-level observations limit causal inference, the consistency of the quantitative and qualitative evidence supports an integrated organizational-capability perspective in which technology improves information and transaction efficiency, governance provides accountability and strategic direction, and aggregation strengthens coordination and market engagement.

Implications for Dairy Cooperative Management and Development

The findings imply that dairy cooperatives should treat technology adoption and governance as complementary capabilities. Cooperatives should invest in affordable, scalable technologies such as electronic payments, computerized records,

digital milk collection, and management information systems, supported by staff training, maintenance, and reliable infrastructure. At the same time, governance should be strengthened through board training, clear board–management roles, financial accountability, regular reporting and auditing, risk management, and performance monitoring.

Member participation and communication should remain central, with digital platforms complementing rather than replacing inclusive cooperative structures. County governments, cooperative-support institutions, development partners, and value-chain actors should promote an integrated approach combining technology, governance, managerial capacity, cooperative education, and market coordination. Sustainable performance therefore depends on combining technological efficiency and improved information flows with strong accountability, leadership, participation, and oversight.

Conclusion

The study concludes that technology adoption and governance significantly contribute to the operational performance of dairy cooperative societies in Kiambu County. Technology adoption had a strong positive relationship with performance ($r = 0.797$, $p < 0.01$; $\beta = 1.070$, $p = 0.042$), while governance also showed a significant positive relationship ($r = 0.649$, $p < 0.01$; $\beta = 0.381$, $p = 0.012$). Digital payments, computerized records, real-time data capture, communication platforms, and dairy management technologies enhance efficiency, accuracy, transparency, coordination, and decision-making. However, the lower governance mean (2.807) compared with technology adoption (3.600) highlights the need to strengthen accountability, board oversight, member participation, leadership, communication, and transparency.

Overall, the findings show that technology and governance are complementary organizational capabilities. The regression model explained 85.7% of the variation in log operational performance, while qualitative evidence indicated that technology delivers greater benefits when supported by effective leadership, staff capacity, accountability, and member participation. Sustainable improvement therefore requires an integrated approach combining affordable digital technologies, capacity development, operational coordination, and stronger governance. Given the cross-sectional design and small number of cooperative-level observations, the findings indicate associations rather than definitive causation. Nevertheless, strengthening technology adoption, governance, and coordination offers a practical pathway to improving the efficiency, transparency, competitiveness, and sustainability of dairy cooperatives in Kiambu County.

Practical and Policy Implications

The findings have important policy and management implications. Government, county governments, cooperative agencies, and dairy regulators should promote technology adoption and good governance jointly through affordable digital infrastructure, reliable connectivity, digital payments, computerized records, real-time milk-data systems, targeted financing, technical support, and digital-skills development. Cooperative programmes should also strengthen board effectiveness, financial accountability, auditing, leadership, succession planning, member participation, transparent

communication, and regular governance assessment, while ensuring secure and interoperable data systems.

At the cooperative level, managers should adopt affordable, scalable technologies suited to their needs and strengthen oversight through transparent reporting, internal controls, performance reviews, auditing, and member feedback. Continuous training for managers, employees, board members, and farmers is essential, while digital platforms should complement rather than replace inclusive participation. Overall, technology, governance, human capacity, and operational coordination should be treated as mutually reinforcing investments to improve efficiency, competitiveness, member confidence, and sustainability.

Study Limitations and Future Research

Limitations of the Study

1. Small sample size: The relatively small number of cooperative-level observations limits the generalizability of the findings.
2. Cross-sectional design: The study captures relationships at one point in time, limiting the ability to establish causal effects.
3. Perception-based measures: Reliance on respondents' perceptions may introduce subjective or response bias.
4. Narrow performance measures: The operational-performance index may not fully capture the broader dimensions of cooperative performance.
5. Geographical scope: The study focused only on dairy cooperatives in Kiambu County, limiting applicability to other regions.
6. Uncontrolled influencing factors: Factors such as cooperative size, financial capacity, market competition, infrastructure, managerial experience, and milk quality were not fully examined.
7. Association rather than causality: The findings demonstrate significant relationships but should not be interpreted as definitive evidence that technology adoption or governance causes improved performance.

Areas for Future Research

1. Larger and broader samples: Future studies should include more cooperatives across multiple counties to improve generalizability.
2. Longitudinal research: Panel studies should examine whether technology adoption and governance improvements produce sustained performance gains over time.
3. Objective measures: Research should incorporate objective indicators of technology use, governance quality, and operational and financial performance.
4. Technology-specific studies: Further research should identify which digital technologies generate the greatest operational benefits and assess their economic returns.
5. Technology–governance interaction: Studies should examine whether governance mediates or moderates the

relationship between technology adoption and performance.

6. Comparative studies: Comparing high- and low-performing cooperatives could identify the organizational, financial, human, and institutional conditions that enable successful technology adoption and governance reforms.

Disclaimer

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Interest Conflicts

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