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Digitalised Risk Management and Firm Performance: An Empirical Analysis of Container Freight Stations in Kenya

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Abstract

The study evaluated the effect of digitalised risk management on the performance of Container Freight Stations (CFSs) in Kenya. Positivism philosophy guided the adoption of cross-sectional survey design. The target population was 38 Container freight Stations in Kenya. The study adopted a census of all 38 licensed CFSs operating in Kenya, with 136 respondents participating structured questionnaires filling. The quantitative data were analysed based on multiple linear regression model with the help of the Statistical Package for Social Sciences version 25. Surveillance technologies significantly and positively affected all performance indicators of CFSs in Kenya. Further, electronic cargo inspection significantly and positively affected revenue growth and operational efficiency aspects of performance of CFSs in Kenya. Finally, gate control system had a weak positive effect on all performance indicators of CFSs in Kenya. The study concluded that the sub constructs of digitalised risk management were jointly positively associated with performance of CFSs in Kenya. The management of CFSs in Kenya should implement non-intrusive inspection technologies, such as X-ray scanners and radiation detectors to minimize clearance times and improve detection capabilities. Further, the Kenya Ports Authority, Kenya Revenue Authority, and the Ministry of Transport ought to mandate or strongly advocate for the implementation of real-time surveillance infrastructure, and electronic cargo inspection technologies as essential operational and security prerequisites for CFS licensing and compliance.

Key Words: digitalised risk management, Firm Performance, Surveillance technologies, electronic cargo inspection, gate control system.

Introduction

Global logistics and container terminal operations are increasingly operating within highly volatile and uncertain environments characterized by intensifying competition, regulatory shifts, technological acceleration, and rapidly evolving customer expectations. Such environmental dynamism compels firms to continuously adapt in order to sustain competitiveness and performance outcomes (Othman et al., 2022; Wibowo & Fransoo, 2023). In logistics systems, performance is understood as the extent to which firms meet stakeholder

expectations through profitability, operational efficiency, cost effectiveness, and service quality improvements (Gituma, 2019). Container freight systems, in particular, are central to global trade facilitation, where performance measurement using indicators such as turnaround time, throughput efficiency, and cost efficiency is critical for identifying operational bottlenecks and improving service delivery (Nikolaou & Dimitriou, 2021; Essel et al., 2022). However, global container terminals continue to experience structural inefficiencies such as congestion, extended dwell times, and limited handling capacity, which undermine logistics efficiency and competitiveness (Bernhofen et al., 2016; Horng et al., 2024). These challenges are further amplified by unpredictable demand patterns and increasing vessel sizes, which strain existing infrastructure and operational systems. In response, digitalised risk management has emerged as a key strategic response, enabling firms to integrate data systems, automate processes, and enhance operational intelligence (Gong & Ribiere, 2021; Koroleva et al., 2020; Heilig et al., 2020). Key components such as data integration, business process automation, and digital risk management are increasingly recognized as essential in improving logistics performance outcomes (Du et al., 2023; Al Yami et al., 2023). Despite these advancements, container freight systems continue to face persistent inefficiencies, particularly in risk anticipation and operational resilience within complex logistics environments (Khan & Efthymiou, 2021).

The empirical literature on digitalised risk management in container terminals reveals a strong convergence on the role of emerging technologies in strengthening risk identification, monitoring, and mitigation across port operations (Cui et al., 2023). Across studies, there is broad agreement that tools such as Radio-Frequency Identification (RFID) - enabled gate systems, Optical Character Recognition (OCR), Closed-Circuit Television (CCTV) surveillance, drones, artificial intelligence, and Internet of Things (IoT-) based cargo tracking significantly enhance operational visibility, security, and efficiency (Mi et al., 2021; Koliousis, 2020; Cunha et al., 2023; Nguyen & Tran, 2024). Similarly, empirical evidence consistently shows that electronic cargo inspection systems and sensor-based tracking improve compliance, reduce inspection time, and enhance logistics performance (Park et al., 2022; Murugi, 2022; Mir et al. (2022). However, despite this convergence, there remains an underlying conceptual fragmentation regarding whether these technologies constitute isolated operational tools or an integrated digitalised risk management system capable of driving firm-level performance outcomes. Most studies remain anchored at the operational or process level, focusing on specific technologies such as gate control systems, surveillance infrastructure, or cargo tracking mechanisms (Lee et al., 2023; Effah et al., 2021). While these contributions demonstrate clear efficiency and security gains, they largely fail to integrate these technologies into a holistic strategic risk management framework. This creates a conceptual gap in understanding how digital risk capabilities collectively translate into sustained competitive advantage and improved firm performance. Methodologically, the literature is dominated by case studies, descriptive designs, and simulation or model-based approaches (e.g., Bayesian networks, ANN forecasting models), which are useful for prediction and system evaluation but limit generalisability across heterogeneous port environments (Tatar et al., 2024; Al Yami et al., 2023; Pöyhönen et al., 2023). Quantitative explanatory studies linking digital risk management to firm performance remain limited, particularly in developing country contexts. Contextually, most evidence is drawn from developed maritime economies or mixed global samples, with relatively fewer integrated empirical investigations in African container terminal environments. This creates a contextual gap given infrastructural constraints, resource limitations, and institutional variability in emerging economies such as Kenya.

This study proposes digitalised risk management as a targeted strategic mechanism for enhancing the performance of Container Freight Stations in Kenya. Digitalised risk management involves leveraging digital technologies to strengthen risk identification, assessment, and mitigation processes within logistics operations, thereby improving operational resilience and decision-making efficiency (Al Yami et al., 2023). Guided by this focus, the study adopted a quantitative methods approach adopting multiple regression analysis to examine the relationships and contextual operational dynamics. The study is geographically delimited to Container Freight Stations operating within Kenya, a logistics environment experiencing intensified competition, infrastructural constraints, and evolving technological adoption. By focusing specifically on digitalised risk management, the study isolates a critical yet underexplored dimension of digital transformation and its influence on firm performance. Digitalised risk management was conceptualised in terms of three sub constructs: gate control system, surveillance technologies, electronic cargo inspection. Further, performance of CFSs in Kenya was operationalised in terms of revenue growth, operational efficiency and customer satisfaction. Additionally, system theory conceptualizes digitalised risk management is comprising of interconnected and interdependent systems, where their effectiveness relies on coordination, control, and feedback mechanisms among subsystems (von Bertalanffy, 1968). Technologies such as electronic cargo inspection and surveillance systems facilitate better integration among security, operations, and logistics functions, thereby minimizing system vulnerabilities and boosting overall efficiency. The study thus sought to test the hypotheses:

H_{O1}: Gate control system has no significant effect on the performance of CFS in Kenya.

H_{O2}: Surveillance technologies have no significant effect on the performance of CFS in Kenya.

H_{O3}: Electronic cargo inspection has no significant effect on the performance of CFS in Kenya.

Methodology

The study was anchored on positivism paradigms to enable a comprehensive examination of the influence of digitalised risk management on performance among CFSs in Kenya. Positivism guided the quantitative strand by facilitating hypothesis testing and objective measurement of relationships among variables (Bell et al., 2022). The study adopted cross-sectional survey design, where quantitative data collected at one point in time across firms was collected. This design was appropriate because it allowed statistical testing of relationships between digitalised risk management and performance. The target population comprised all 38 Container Freight Stations operating in Kenya. The CFSs formed the unit of analysis. Five functional managers were purposively selected from each CFS, drawn from Operations, Information and Communications Technology (ICT), General Management, Human Resources, and Clearing and Forwarding departments. This yielded a total of 190 respondents ($38 \times 5 = 190$). The choice to select five respondents from each CFS was based on the necessity to gather varied managerial insights from the essential functional areas.

Primary data were collected using structured questionnaires finetuned on a 5-point Likert scale. The questionnaires captured measurable indicators of digitalised risk management and firm performance. A pilot study was conducted among 20 respondents from four randomly selected CFSs, which were later on excluded from the final study. The pilot findings were used to assess reliability and validity of the research instruments. Internal consistency was evaluated using Cronbach's alpha, with results showing strong reliability for all constructs: gate control system (0.962), surveillance technologies (0.925), electronic cargo inspection (0.922), revenue growth

(0.879), operational efficiency (0.890) and customer satisfaction (0.785). Construct validity was assessed using Average Variance Extracted (AVE), where all constructs recorded AVE values above 0.60, confirming adequate convergent validity. Ethical approval was obtained from the University International Social Research Ethics Committee (USIU), followed by authorization from the National Commission for Science, Technology and Innovation. Informed consent was obtained from all respondents prior to participation, and participation was voluntary, with respondents retaining the right to withdraw at any stage without penalty. Confidentiality was strictly maintained through anonymization using codes, secure password-protected data storage, and restricted access limited to the principal investigator. Physical questionnaires were securely destroyed after completion and approval of the thesis.

Quantitative data were coded and entered into Statistical Package for Social Sciences (SPSS) version 25 for analysis. Descriptive statistics, including means, standard deviations, and percentages, were used to summarize the data. Prior to inferential analysis, diagnostic tests were conducted to ensure the robustness of regression models, including tests for normality, autocorrelation, homoscedasticity, multicollinearity, and linearity. Inferential analysis involved correlation analysis and multiple linear regression to test the hypothesized relationships. Hypothesis testing was based on t-statistics and p-values, where significance was determined at $t > \pm 1.96$, leading to rejection or failure to reject the null hypothesis. The study thus estimated the model in equation one.

$$FP_1 = \beta_0 + \beta_1 DRM_1 + \beta 2 DRM_2 + \beta 3 DRM_3 + \varepsilon \text{.....(1)}$$

$$FP_2 = \beta_0 + \beta_1 DRM_1 + \beta 2 DRM_2 + \beta 3 DRM_3 + \varepsilon \text{.....(2)}$$

$$FP_3 = \beta_0 + \beta_1 DRM_1 + \beta 2 DRM_2 + \beta 3 DRM_3 + \varepsilon \text{.....(3)}$$

Where FP = FP= Firm Performance (FP_1= revenue growth, FP_2= operational efficiency, FP_3= customer satisfaction), β_0 = Intercept Term, DRM = Digitalised Risk Management (DRM_1= gate control system, DRM_2= surveillance technologies, DRM_3= electronic cargo inspection), β_1=β_3= Coefficients of DRM and ε= Error Term.

Results

The study issued 170 questionnaires to various management staff spread in 34 Container Freight Stations in Kenya after 20 respondents from 4 CFSs were excluded from the final study after having participated in the pilot study. Of the number of questionnaires issued, 136 were received back having been filled adequately for further analysis. The response translated to a response rate of 80% which was considered adequate for further analysis. Nulty (2008) found that paper-based surveys had higher response rates (50–70%) compared to online surveys (20–30%). The analysis of objectives included preliminary tests, descriptive and inferential statistics.

Descriptive Statistical Analysis

The descriptive analysis of the sub constructs of digitalised risk management was based on responses on 5-point Likert Scale where 1 was Not at All, 2 was Small Extent, 3 was Moderate Extent, 4 was Large Extent and was 5 was very large extent. The responses were then analysed using percentages, mean and standard deviation. The sub construct of digitalised risk management analysed included: gate control system, surveillance technologies and electronic cargo inspection.

Gate Control System

Table 1 presents descriptive findings on gate control systems as an element of digitalised risk management CFSs in Kenya, indicating moderate overall adoption. Automated gates controlling entry and exit were reported to a large extent by 50.8% of respondents (μ=3.49, σ=0.95), while 48.5% indicated gates that open or close based on authorisation (μ=3.44, σ=0.98). Security effectiveness was relatively stronger, with 55.1% confirming that gates ensure only authorised persons and vehicles access facilities (μ=3.65, σ=1.03). Licence plate recognition at gates was supported by 54.4% (μ=3.49, σ=1.16), though automation remained moderate. Only 44.9% reported tagging of vehicles/containers for automatic recognition (μ=3.36, σ=1.17), indicating limited implementation. Camera-based identification was noted by 47.8% (μ=3.39, σ=1.17), while alert systems for unauthorized entry were reported by 47.7% (μ=3.37, σ=1.15). Similarly, 47.7% confirmed automated vehicle identification. Finally, 55.9% indicated improved traffic flow management at gates (μ=3.50, σ=1.09). Findings suggest that gate control systems in Kenyan CFSs are moderately deployed, with stronger performance in access control and traffic management but weaker integration in full automation and real-time identification technologies.

Table 1

Gate Control System aspect of Digitalised Risk Management

Statements (n=136	**Not at all (%)**	**Small Extent (%)**	**Moderate Extent (%)**	**Large Extent (%)**	**Very Large Extent (%)**	**μ**	**σ**
We have installed automated gates to control entrance/exists.	3.7	8.1	37.5	36.8	14.0	3.49	0.95
The gates automatically open or close based on authorization.	4.4	8.8	38.2	35.3	13.2	3.44	0.98
Only authorized persons can enter or exit securely.	2.2	10.3	32.4	30.1	25.0	3.65	1.03
The gate system automatically reads vehicle license plates.	7.4	11.8	26.5	33.1	21.3	3.49	1.16
The gate automatically recognises Tracks and containers	8.1	12.5	34.6	25.0	19.9	3.36	1.17
The gate system uses cameras to identify vehicle license plates.	8.1	12.5	31.6	27.9	19.9	3.39	1.17
The gate system sends alerts to operators for unauthorized entry.	8.1	12.5	31.6	30.1	17.6	3.37	1.15
The firm has automated vehicle identification at the gates.	8.1	8.1	36.0	30.1	17.6	3.41	1.11
The gate manages the flow of vehicles waiting to enter or exit.	4.4	15.4	24.3	37.5	18.4	3.5	1.09
Overall mean						3.45	1.09

Surveillance Technologies

Table 2 presents descriptive findings on surveillance technologies as a component of digitalised risk management in Container Freight Stations (CFSs) in Kenya. Overall, the results indicate

a moderately high but uneven adoption of surveillance technologies, with strong implementation in physical monitoring systems and weaker integration in advanced digital surveillance and cyber protection tools. Findings show that 57.4% of respondents reported the use of biometric systems for staff identification, with a mean of 3.76 ($\sigma = 0.93$), indicating relatively strong adoption for personnel authentication. Similarly, 57.7% indicated that access to different facility sections requires specified authorization, reflected in a mean of 3.70 ($\sigma = 0.99$), suggesting structured internal access control. Only 43.3% of respondents reported the use of aerial surveillance such as drones, with a mean of 3.27 ($\sigma = 1.17$), indicating moderate utilization. Cybersecurity capabilities were also relatively weak, as only 44.1% confirmed robust cyber threat detection and prevention systems ($\mu = 3.36$, $\sigma = 1.08$), implying moderate preparedness against cyber risks. In contrast, traditional surveillance tools were more widely adopted. CCTV cameras were installed across entry points, cargo areas, and perimeters, as reported by 68.9% of respondents ($\mu = 4.11$, $\sigma = 1.01$), with 58.8% confirming 24-hour operation. Additionally, 55.9% indicated that vehicles and trucks are fitted with tracking devices ($\mu = 3.66$, $\sigma = 1.02$), enhancing cargo monitoring. Record-keeping practices were also relatively strong, with 61.8% reporting that firms maintain detailed records of vehicles, drivers to facilitate faster check-in ($\mu = 3.82$, $\sigma = 0.96$).

Table 2

Surveillance technologies aspect of digitalised risk management

Statement (n=136)	Not at all (%)	Small Extent (%)	Moderate Extent (%)	Large Extent (%)	Very Large Extent (%)	μ	σ
The firm has installed biometrics system for staff identification and authentication.	0.0	8.1	34.6	30.9	26.5	3.76	0.93
Access to different parts of the organization requires specified authentications.	0.0	13.2	29.4	31.6	25.7	3.7	0.99
We use aerial surveillances technologies like drones for monitoring the facility.	6.6	20.6	29.4	25.7	17.6	3.27	1.17
We have robust cyber threat detection and prevention.	5.1	14.7	36.0	27.2	16.9	3.36	1.08
We have installed CCTV cameras for monitoring facility.	.7	8.8	21.6	26.5	42.4	4.11	1.01
The installed CCTV system is working around the clock.	1.5	5.1	34.6	25.0	33.8	3.85	1.00
Tracks accessing the facility are fitted with tracking devices.	2.2	9.6	32.4	31.6	24.3	3.66	1.02
We maintain records of vehicles and drivers for faster check-in.	.7	7.4	30.1	32.4	29.4	3.82	0.96
Overall mean						3.65	1.02

Electronic Cargo Inspection

Move this section above the table. Electronic cargo inspection (Table 3) within digitalised risk management shows moderate to strong adoption among CFSs in Kenya. A majority of respondents (55.1%) indicated extensive use of X-ray and gamma ray machines for cargo inspection, reflected in a mean of 3.60 (σ=1.16), suggesting moderate technological readiness. Cyber risk identification training was also widely practiced, with 45.6% support and a mean of 3.51 (σ=1.01). Use of electronic container seals to monitor integrity and detect tampering was reported by 52.2% of respondents (μ=3.56, σ=1.11), indicating relatively strong implementation. Real-time container tracking was less advanced, with a mean of 3.49 (σ=0.95), implying only moderate capability. Automated reading of container numbers and shipment details remained relatively weak (μ=3.31, σ=1.02). However, automated cargo weighing systems were widely adopted (55.2%, μ=3.65, σ=1.22), and automated data extraction for cross-referencing cargo information was also strong (55.9%, μ=3.64, σ=1.05), indicating growing digitisation in inspection and verification processes.

Table 3

Electronic Cargo Inspection aspect of digitalised risk management

Statements (n=136)	Not at all (%)	Small Extent (%)	Moderate Extent (%)	Large Extent (%)	Very Large Extent (%)	μ	σ
The firm uses technologies such as X-ray for cargo inspection.	5.9	10.3	28.7	27.9	27.2	3.6	1.16
We offer periodic training to staff on cyber risk prevention.	2.2	11.0	41.2	24.3	21.3	3.51	1.01
Electronic Seals Monitors the integrity of container.	4.4	11.8	31.6	27.9	24.3	3.56	1.11
We use real-time tracking of containers from entry to exit.	2.2	11.8	35.3	36.0	14.7	3.49	0.95
We have automated capture of container details via License Plate and barcode scanning.	5.1	14.0	37.5	31.6	11.8	3.31	1.02
Automated cargo weighing is used to verify container weights.	5.9	11.8	27.2	22.1	33.1	3.65	1.22
The system automatically extracts data from scanned documents for cross-referencing.	2.9	10.3	30.9	31.6	24.3	3.64	1.05
Overall Mean						3.53	1.07

Descriptive Analysis of Performance of Container Freight Stations in Kenya

The descriptive findings in Table 4 indicate a generally positive performance trajectory among Container Freight Stations (CFSs) in Kenya across revenue growth, operational efficiency, and customer satisfaction dimensions. Based on responses from 136 participants (n=136), the composite mean score of 3.66 (σ = 1.00) reflects a moderate but consistent perception of

improved firm performance between 2021 and 2024. Revenue performance indicators show upward movement across key streams. Profit growth recorded the highest agreement (μ = 3.83, σ = 0.98), with 55.9% of respondents confirming consistent increases. Non-demurrage revenues also demonstrated stable growth (μ = 3.71, σ = 0.93; 55.1% agreement), while demurrage fee collections improved moderately (μ = 3.65, σ = 0.97; 51.5% agreement). Operational efficiency gains are further evidenced by improved cargo clearance times, with most firms maintaining clearance within the 60-hour threshold set by regulatory expectations, reflected in a mean of 3.83 (σ = 0.99) and 65.5% agreement. Truck turnaround times similarly declined (μ = 3.79, σ = 0.98), and capacity utilisation remained strong, with firms operating above 70% of installed capacity (μ = 3.66, σ = 1.02). Cost efficiency improvements were also noted, as 52.2% of respondents reported a steady reduction in operational costs relative to profits (μ = 3.61, σ = 0.95). Despite these gains, contraband cargo incidences were perceived to have increased, though only moderately (μ = 3.35, σ = 1.07; 47.0% agreement), suggesting emerging pressure on risk control systems. Customer-related outcomes were largely positive, with declining customer attrition (μ = 3.84, σ = 1.05) and rising repeat clientele (μ = 3.76, σ = 1.05). Customer satisfaction also improved (μ = 3.77, σ = 1.05), alongside gains in labour productivity (μ = 3.79, σ = 0.99). Innovation remained steady, with continued introduction of new service offerings (μ = 3.57, σ = 1.01). However, market share dynamics present a contrasting pattern, as perceptions of declining market share (μ = 3.20, σ = 1.04; 45.6% agreement) suggest increasing competitive pressure and possible market fragmentation despite internal performance gains.

Table 4

Descriptive Analysis of Performance of Container Freight Stations in Kenya

Statement (n=136)	Strongly Disagree (%)	Disagree (%)	Some what Agree (%)	Agree (%)	Strongly Agree (%)	μ	σ
Revenue growth							
Your firm's profits have increased consistently from 2021 to 2024.	0.0	6.6	37.5	22.1	33.8	3.83	0.98
Demurrage fees collection has increased from 2021 to 2024.	0.7	8.8	39.0	27.2	24.3	3.65	0.97
Non- demurrage revenues have increased from 2021 to 2024.	0.7	6.6	37.5	31.6	23.5	3.71	0.93
Operational Efficiency							
Your firm's cargo clearance time is below 60 hours recommended by KPA.	1.5	8.1	25.0	36.8	28.7	3.83	0.99
Our truck turnaround time has reduced significantly from 2021 to 2024.	0.0	11.0	27.2	33.8	27.9	3.79	0.98
Our contraband cargo incidents have increased from 2021 to 2024.	2.2	23.5	27.2	31.6	15.4	3.35	1.07
Our operational cost ratio has been declining from 2021 to 2024.	0.7	10.3	36.8	31.6	20.6	3.61	0.95
Your firm's facility is operating above 70% of its design capacity.	2.2	8.8	34.6	29.4	25.0	3.66	1.02

Customer Satisfaction							
Our market share has been declining consistently from 2021 to 2024.	5.1	22.8	26.5	38.2	7.4	3.2	1.04
Your firm has consistently introduced new products from 2021 to 2024.	1.5	13.2	33.1	31.6	20.6	3.57	1.01
Our labour productivity has increased significantly from 2021 to 2024.	0.7	10.3	25.7	35.3	27.9	3.79	0.99
Our repeated customers have risen consistently from 2021 to 2024.	2.9	5.9	34.6	25.7	30.9	3.76	1.05
Our customer satisfaction scores rose consistently from 2021 to 2024.	2.2	8.8	28.7	30.1	30.1	3.77	1.05
Customer attrition has been declining consistently from 2021 to 2024.	2.9	5.9	28.7	29.4	33.1	3.84	1.05
Overall Mean						3.66	1.00

Diagnostic Tests

Tests of normality revealed that all study variables were approximately normally distributed. The Kolmogorov–Smirnov statistics ranged from 0.061 to 0.078 ($p > .05$), while the Shapiro–Wilk statistics ranged from 0.981 to 0.989 ($p > .05$). Since all significance values exceeded the threshold of 0.05, the assumption of normality was satisfied, supporting the use of parametric analyses. The variance inflation factor (VIF) measure of multicollinearity showed that the independent variables had VIF values less than 5: gate control system (3.93), surveillance technologies (2.72) and electronic cargo inspection (3.54). The VIF values were below the threshold of 5, indicating the absence of severe multicollinearity. The Breusch–Pagan test conducted across all three multiple regression models (1-3) confirmed that the error variances were homoscedastic (p-values >0.05). The Ramsey RESET test result for the functional form misspecification was not statistically significant ($p > 0.05$), suggesting that the linear functional form was appropriate. Finally, Harman's single-factor test for common method variance revealed multiple factors with eigenvalues greater than 1, and the first factor accounted for 35.8% of the total variance, which is below the recommended threshold of 50%. This suggests that common method variance was not a significant concern in the study.

Regression Analysis

To ascertain the empirical link between digitalized risk management and organizational performance, a tri-variate ordinary least squares (OLS) regression analysis was conducted. The framework evaluated the predictive capacity of three distinct risk management constructs namely, gate control systems, surveillance technologies, and electronic cargo inspection across three core performance dimensions: revenue growth (Y_1), operational efficiency (Y_2), and customer satisfaction (Y_3).

Table 5

Linear Regression Output

Predictors / Diagnostics	**Revenue Growth (Y_1)**	**Operational Efficiency (Y_2)**	**Customer Satisfaction (Y_3)**
(Constant)	0.476***	0.479***	0.512***
	(0.179)	(0.175)	(0.195)
Gate Control	0.126	0.086	0.077
System	(0.081)	(0.079)	(0.088)
Surveillance	0.498***	0.573***	0.625***
Technologies	(0.078)	(0.076)	(0.084)
Electronic Cargo	0.282***	0.219**	0.168
Inspection	(0.103)	(0.101)	(0.112)
R^2	0.727	0.723	0.675
Adjusted R^2	0.721	0.716	0.667
F-Statistic	117.236	114.624	91.256
Model Significance (p-value)	.000***	.000***	.000***

Significance Levels *** $p < 0.01$ ** $p < 0.05$ *$p < 0.10$, Standard errors are in parentheses

$$FP_1=\beta_0+0.126DRM_1+0.498DRM_2+0.282DRM_3+\varepsilon \quad \ldots\ldots[1]$$

$$FP_2=\beta_0+0.086DRM_1+0.573DRM_2+0.219DRM_3+\varepsilon \quad \ldots\ldots[2]$$

$$FP_3=\beta_0+0.077DRM_1+0.625DRM_2+0.168DRM_3+\varepsilon \quad \ldots\ldots[3]$$

The results indicate that the three digitalized risk management components jointly explained 72.7%, 72.3%, and 67.5% of the variations in revenue growth, operational efficiency, and customer satisfaction, respectively. The corresponding models were statistically significant, with F-statistics of 117.236, 114.624, and 91.256 ($p < 0.001$), confirming the suitability of the models for hypothesis testing. Among the predictors, surveillance technologies emerged as the most influential factor across all performance dimensions, recording positive and statistically significant coefficients of $\beta_2 = 0.498$ ($t = 6.416$, $p < 0.001$), $\beta_2 = 0.573$ ($t = 7.549$, $p < 0.001$), and $\beta_2 = 0.625$ ($t = 7.418$, $p < 0.001$) for revenue growth, operational efficiency, and customer satisfaction, respectively. These findings suggest that enhanced monitoring and real-time visibility contribute significantly to improved financial, operational, and customer-related outcomes. Electronic cargo inspection also demonstrated a positive and significant effect on revenue growth ($\beta_3 = 0.282$, $t = 2.738$, $p = 0.007$) and operational efficiency ($\beta_3 = 0.219$, $t = 2.173$, $p = 0.032$), respectively, but did not significantly influence customer satisfaction ($\beta_3 = 0.168$, $t = 1.497$, $p = 0.137$). This implies that while automated cargo inspection enhances revenue collection and operational processes, its benefits may not be directly perceived by customers. Conversely, gate control systems recorded positive but statistically insignificant coefficients of $\beta_1 = 0.126$ ($p = 0.121$), $\beta_1 = 0.086$ ($p = 0.276$), and $\beta_1 = 0.077$ ($p = 0.383$) for revenue growth, operational efficiency, and customer satisfaction, respectively. The findings

suggest that although gate control systems contribute to access management and security, they do not independently exert a significant influence on organizational performance outcomes.

Discussion of Findings

The findings demonstrate that digitalized risk management contributes significantly to organizational performance, although the magnitude of influence varies across its dimensions. Surveillance technologies constitute the most critical risk management capability, exerting a consistently positive and significant effect on revenue growth, operational efficiency, and customer satisfaction. This finding supports the argument that enhanced visibility, real-time monitoring, and rapid risk detection reduce operational disruptions, improve resource utilization, and strengthen customer confidence. Electronic cargo inspection emerged as a complementary capability, significantly improving revenue growth and operational efficiency but not customer satisfaction. The results suggest that its benefits are largely internal, enhancing cargo verification accuracy, reducing processing delays, and minimizing revenue leakages without directly affecting customer perceptions. In contrast, gate control systems did not significantly influence any of the performance dimensions examined. This indicates that access-control technologies may function as foundational operational requirements rather than strategic resources capable of generating measurable competitive advantages. Overall, the results suggest that organizations seeking to enhance performance through digitalized risk management should prioritize investments in surveillance technologies while electronic cargo inspection can provide additional operational and financial benefits. The findings align with Mir et al. (2022), who observed that AI-enabled digital identity systems enhance stakeholder protection by mitigating identity theft, unauthorized access, and credential misuse while improving empowerment opportunities. Similarly, Tatar et al. (2024) showed that cyber risk analysis in maritime transport systems provides effective evaluation of risks at both tactical and strategic levels, offering quantitative metrics that support informed decision-making. Pöyhönen et al. (2023) emphasize the importance of modelling attack probabilities to secure system components against anticipated cyber threats across port operations. Cui et al. (2023) argue that digitalized risk management enables holistic risk analysis, supporting unified safety models that improve real-time and system-wide risk assessment and prediction. Koliousis (2020) highlights that Automated Border Control systems strengthen Port Community Systems by improving information sharing and inter-agency collaboration in security processes. Khan and Efthymiou (2021) demonstrate that biometric surveillance enhances identity verification, reduces fraud, and improves monitoring of entry and exit processes in ports and airports. Mi et al. (2021) further show that vision-based surveillance systems reduce operational costs while improving throughput and security. Collectively, these findings support Systems Theory (von Bertalanffy, 1968), which views organizations as interdependent subsystems. Digitalized risk management strengthens coordination, feedback, and control mechanisms across CFS operations, thereby reducing vulnerabilities and improving overall organizational performance. Furthermore, the findings align with Systems Theory.

Conclusion

This study examined the effect of digitalised risk management on the performance of Container Freight Stations in Kenya. The study aliened to Systems Theory was based on positivism philosophy and cross-section survey design with multiple linear regression being adopted in examining the relationship between outcome and predictors variables. Surveillance technologies as an aspect of digitalised risk management had a strong and positive association with performance of CFSs in Kenya. Therefore, real-time risk surveillance lower transactional friction and mitigate asset loss, directly reflecting on bottom-line and perception metrics.

Further, the effect of electronic cargo inspection on performance as measured by revenue growth and operational efficiency of CFSs in Kenya. Thus, electronic cargo inspection selectively serves CFSs in boosting revenue collection capabilities and process efficiency but its utility diminishes when directly mapped against customer satisfaction metrics. Finally, the consistent statistical insignificance of gate control systems suggests that automated access systems may function as a baseline factor rather than a strategic driver of performance of CFSs in Kenya. Strategic resource allocation should, therefore, prioritize deep-tier surveillance technologies and electronic cargo inspection infrastructure to secure localized performance wins among CFSs in Kenya. The study recommends to management of CFSs in Kenya to implement non-intrusive inspection technologies, such as X-ray scanners and radiation detectors to minimize clearance times and improve detection capabilities. Further, these systems can be integrated with Integrated customs management system (iCMS), granting customs officers immediate access to cargo inspection data. This not only accelerates the inspection process but also aids in more effectively identifying undervalued, mis declared, or prohibited items. KRA should take the initiative in deploying these systems across all CFSs, ensuring that customs staff and CFS personnel receive proper training in their use. From a policy standpoint, the Kenya Ports Authority, Kenya Revenue Authority, and the Ministry of Transport ought to emphasize the establishment of digital risk management standards throughout all container freight stations. Policy frameworks should either mandate or strongly advocate for the implementation of real-time surveillance infrastructure, and electronic cargo inspection technologies as essential operational and security prerequisites for CFS licensing and compliance. Such regulatory initiatives would bolster cargo security, diminish pilferage, enhance customs clearance efficiency, and alleviate operational disruptions, thus converting digital risk controls into quantifiable performance improvements.

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