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Effect of Electronic Cargo Tracking System Implementation on Trade Facilitation at the Inland Container Depot, Nairobi, Kenya

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Abstract

The purpose of the study was to evaluate the impact of ECTS implementation on trade facilitation outcomes at ICD Nairobi, Kenya. An explanatory research design was adopted, targeting a population of 2,100 customs officers, clearing agents, and logistics providers, from which a stratified random sample of 325 respondents was selected. Data were collected through structured questionnaires, cleaned through psychometric tests, and subjected to diagnostic tests to confirm regression assumptions. Both descriptive and inferential statistical techniques were used, including correlation analysis and multiple regression models. The results demonstrated that technological infrastructure had a significant positive effect on trade facilitation ($\beta = 0.374$, $p = 0.001$), confirming the value of stable connectivity and robust ICT systems. System features, including GPS monitoring, electronic seals, and automated alerts, also showed a strong positive impact ($\beta = 0.382$, $p = 0.000$). Based on this, this study concludes that enhancing technological infrastructure, such as improved system integration level, network connectivity quality, real-time data processing capability, and API integration capabilities at Nairobi ICD, would improve trade. The study also observed that system features have a positive and statistically significant effect on trade facilitation. Based on this study's findings, the study concludes that enhanced system features by improving GPS tracking precision, electronic seal technology, alert management system, and document digitization level will increase trade facilitation. Based on the above conclusions, the study suggests that ICD should strengthen its system integration and connectivity, enhance system features, provide continuous training, and improve organizational support, all of which would ensure improved trade facilitation.

Keywords: *Electronic cargo tracking system, technological infrastructure, system features, trade facilitation*

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1. Introduction

Global trade systems have increasingly embraced digital technologies as enablers of efficiency, transparency, and competitiveness in cross-border logistics. Trade facilitation, the simplification and harmonization of international trade procedures, is now widely recognized as a critical pillar for economic growth and global integration, especially for countries seeking to reduce transaction costs and enhance customs efficiency. According to the World Trade Organization (2022), the implementation of digital trade facilitation measures can lower trade costs by up to 14.3%, while also accelerating cargo clearance and improving regulatory compliance. Developed countries such as Singapore, the Netherlands, and the United States have pioneered the use of integrated cargo tracking technologies that utilize global positioning systems (GPS), blockchain, geofencing, and artificial intelligence to monitor cargo in real time, reduce theft, and enable pre-arrival customs processing (Kim & Lee, 2023; García-Menéndez & de Langen, 2022). These systems are supported by robust technological infrastructure, institutional coordination, and policy frameworks that promote efficiency and data-driven enforcement.

At the continental level, Africa has begun a digital transition under the framework of the African Continental Free Trade Area (AfCFTA), which aims to eliminate non-tariff barriers and promote intra-African trade through improved border management and logistics systems. Recognizing the critical role of ICT in customs modernization, the African Union's Digital Transformation Strategy for Africa (2020–2030) encourages the adoption of digital customs systems, including electronic cargo tracking, to boost operational transparency, combat smuggling, and increase revenue collection (African Multidisciplinary Tax Journal, 2024). Empirical studies across the continent have reported a 25–30% reduction in transit delays and up to a 40% improvement in inter-agency communication following the adoption of electronic tracking systems (Wanjiru & Mutua, 2022). However, the realization of these benefits remains uneven due to infrastructural disparities, weak human resource capacity, and fragmented regulatory implementation across African states (Ngugi, 2022).

At the regional level, the East African Community (EAC) has taken a pioneering role in harmonizing electronic cargo monitoring through the Regional Electronic Cargo Tracking System (RECTS), which integrates customs authorities in Kenya, Uganda, and Rwanda. RECTS enables joint real-time tracking of transit goods, reducing the risk of cargo diversion, enhancing inter-country customs cooperation, and significantly shortening border clearance times (Dongo & Rono, 2023). The system has contributed to improved cargo security and better visibility of goods along key regional corridors such as the Northern Corridor, which connects the port of Mombasa to inland destinations. Despite these gains, disparities remain in system adoption and user competence among EAC member states, reflecting broader challenges of institutional capacity, infrastructure investment, and technical training (Wambua & Ouma, 2022).

In Kenya, the Electronic Cargo Tracking System (ECTS) was introduced by the Kenya Revenue Authority (KRA) in 2013 to address longstanding challenges in customs management, including cargo misrouting, revenue leakage, and inefficient clearance processes. The system has yielded notable improvements in cargo traceability and compliance monitoring, particularly along the Mombasa–Nairobi–Malaba route, which handles a majority of Kenya's regional trade volumes (Odhiambo & Wanyama, 2018; KRA, 2024). However, the

performance of ECTS at the Inland Container Depot (ICD) Nairobi, a key inland logistics hub, has remained sub-optimal. Studies by Mburu and Ngigi (2023) reveal that up to 35% of cargo tracking disruptions at ICD Nairobi are linked to last-mile connectivity issues, inconsistent system integration, and user-related errors. Moreover, inadequate training among customs officials, limited inter-agency coordination, and unclear standard operating procedures (SOPs) further constrain the full realization of ECTS benefits at this strategic inland node (Kamau & Njoroge, 2021; Inter-Agency Coordination at ICD Nairobi, 2022).

To address these implementation challenges and performance gaps, this study focused on four key dimensions influencing ECTS effectiveness: technological infrastructure, system features, human resource capacity, and organizational factors. Technological infrastructure refers to the underlying digital ecosystem that supports ECTS operations, including network reliability, system integration, and data processing capabilities (Kimani & Ochieng, 2019). System features include operational functionalities such as GPS tracking precision, electronic seal technology, real-time alert systems, and document digitization (Ouma & Kamau, 2020).

Human resource capacity encompasses the technical competencies, digital literacy, and training levels of customs officials and logistics providers responsible for system use. Research shows that insufficient training leads to underutilization, while tailored capacity-building initiatives can boost adoption and reduce operational errors by over 50% (Digital Literacy in East Africa, 2023). Organizational factors refer to institutional readiness, management support, policy alignment, and resource allocation, all of which are necessary for sustaining and institutionalizing ECTS within the broader customs and logistics framework (Wambua & Ouma, 2022; Scott, 2008).

These variables collectively influence the broader construct of trade facilitation, which in this study is operationalized through indicators such as reduced clearance times, improved cargo security, increased customs revenue, and enhanced supply chain efficiency (World Bank, 2020). Importantly, the relationship between ECTS implementation and trade facilitation outcomes is not merely technical, but shaped by user behavior, institutional governance, and operational practices. Through this multidimensional lens, the study aimed to generate empirical insights that can inform policy reforms, capacity-building strategies, and technological investments to optimize ECTS performance and enhance trade facilitation outcomes at ICD Nairobi.

1.1 Problem Statement

The trade facilitation ecosystem at the Nairobi ICD suffers from significant operational bottlenecks that weaken its efficiency and regional competitiveness. Long cargo clearance time, cumbersome documentation processes, and lack of real-time cargo visibility are some of the major barriers to smooth international trade operations (World Bank, 2020; UNCTAD, 2023). These challenges are exacerbated by fragmented information systems, inconsistent technological implementation, and complex administrative procedures, resulting in increased processing delays, elevated logistics costs, and diminished transparency (Ochieng & Kemboi, 2020). The absence of integrated tracking mechanisms further compounds inefficiencies, hindering Kenya's ambition to solidify its position as a competitive trade hub in East Africa.

While the ECTS has been implemented to address these challenges, gaps remain in ensuring its optimal performance. Studies indicate that poor last-mile connectivity has reduced the efficiency of real-time tracking, with network down-times at ICD Nairobi affecting 35% of

recorded transit operations (Mburu & Ngigi, 2023). Additionally, interoperability challenges between Kenya's ECTS and those of neighboring countries have led to inconsistencies in data exchange, limiting its effectiveness in regional trade facilitation (Dongo & Rono, 2023).

Furthermore, inadequate user training has resulted in systems underutilization, with 60% of customs officials reporting a lack of advanced skills in ECTS usage (KESRA, 2024). This aligns with findings by Mutua and Kamau (2021), who noted that training gaps in digital tracking systems reduce system efficiency by up to 35%. In contrast, studies from OECD countries show that continuous training programs improve system utilization rates by 55% and decrease operational errors by 40% (Customs Digitization in OECD Countries, 2023).

Institutional and organizational barriers also present significant challenges. Wambua et al. (2018) highlight that fragmented policy frameworks, inadequate interagency coordination, and bureaucratic inefficiencies reduce the effectiveness of ECTS implementation. In Kenya, inter-agency coordination at ICD Nairobi has improved operational efficiency by 40%, yet regulatory inconsistencies and slow policy adoption continue to hinder full optimization (Inter-Agency Coordination at ICD Nairobi, 2022). Addressing these challenges through enhanced governance structures, targeted capacity-building initiatives, and policy harmonization is crucial for improving ECTS performance and maximizing its impact on trade facilitation.

By integrating insights from recent and earlier studies, this research aims to provide a comprehensive analysis of the persistent challenges affecting ECTS implementation at ICD Nairobi. Understanding these gaps and formulating targeted interventions to improve system adoption, infrastructure reliability, and inter-agency collaboration is essential for enhancing trade facilitation outcomes in Kenya.

1.2 Research Objectives

i. To assess the influence of technological infrastructure on the effectiveness of ECTS on trade facilitation at ICD Nairobi, Kenya.

ii. To examine how system features impact operational efficiency of the ECTS on trade facilitation at ICD Nairobi, Kenya.

1.3 Research Hypotheses

i. H_{01}: Technological infrastructure of ECTS at ICD Nairobi has no statistically significant effect on trade facilitation.

ii. H_{02}: System features of ECTS have no statistically significant effect on Trade facilitation at ICD Nairobi.

2. Literature Review

2.1 Theoretical Review

2.1.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) developed by Davis (1989) remains one of the most influential frameworks in technology adoption research. It suggests that users' decisions to adopt a technology are determined primarily by perceived usefulness and perceived ease of use. In customs modernization, perceived usefulness can be linked to whether ECTS reduces clearance time or improves cargo security, while perceived ease of use relates to whether customs officers, clearing agents, and logistics operators find the system user-friendly.

Several studies have applied TAM in similar contexts. Venkatesh and Bala (2008) extended TAM to show that organizational support and training influence perceived ease of use. In East Africa, Bwire (2019) applied TAM to study the adoption of electronic single window systems in Uganda, concluding that the lack of training limited adoption despite the system's clear benefits. By anchoring this study in TAM, the analysis emphasizes the behavioral and perceptual aspects of system uptake, which are often overlooked in purely technical evaluations.

Beyond its original formulation, subsequent studies have highlighted the importance of organizational support in shaping technology acceptance. Venkatesh and Bala (2008) argue that perceived ease of use is strongly mediated by the quality of training and technical support offered to users. In the context of ECTS, customs officers and clearing agents are more likely to adopt and effectively utilize the system when they are confident in their ability to navigate its functions. This reinforces the relevance of TAM in understanding user behavior within customs modernization.

2.1.2 Diffusion of Innovation (DOI) Theory

Building upon the understanding of individual technology adoption, the Diffusion of Innovation (DOI) Theory, proposed by Rogers (2003), explains how technological innovations spread across different user groups over time. According to Rogers, adopters of technology can be classified into five categories: innovators, early adopters, early majority, late majority, and laggards. The speed at which an innovation is adopted depends on factors such as relative advantage, compatibility with existing systems, complexity, trialability, and observability. Regional experiences illustrate the explanatory power of DOI theory. Mutalemwa (2017), for example, shows that Rwanda's decision to accelerate ECTS adoption was strongly influenced by Uganda's prior success in curbing cargo diversion, demonstrating the mimetic effect described by Rogers. Similarly, peer benchmarking across the EAC has encouraged harmonization through the Regional Electronic Cargo Tracking System (RECTS). This suggests that DOI provides not only a micro-level but also a meso-level explanation of adoption patterns within regional blocs. In Kenya, large-scale logistics companies and regulatory bodies have been early adopters of ECTS, while small-scale traders and independent transporters have exhibited slower adoption due to financial constraints and technological barriers. The DOI Theory is particularly useful in explaining the disparities in ECTS adoption across different actors in the trade sector. Large enterprises that have integrated ECTS into their operations have experienced significant efficiency improvements, while smaller traders struggle with the financial burden of system integration and technical expertise requirements. Critics of the DOI Theory argue that it oversimplifies the adoption process by assuming a linear progression without adequately addressing resistance factors such as economic policies, digital illiteracy, and institutional inertia (Lyytinen & Damsgaard, 2001). Additionally, DOI does not fully account for the role of policy enforcement in technology diffusion, which is a critical factor in ECTS implementation. Despite these critiques, DOI Theory remains relevant in examining the adoption of ECTS at ICD Nairobi by categorising stakeholders based on their readiness and response to new technologies. This study leverages DOI Theory to assess how adoption patterns can be improved through targeted policy interventions, training programmes, and incentives for late adopters.

2.2 Empirical Review

Globally, technological infrastructure is a cornerstone of efficient trade facilitation. Studies indicate that robust digital infrastructure can reduce customs clearance times by up to 50% and boost trade volumes by 15% within two years (Digital Progress and Trends Report, 2023). The integration of ECTS in customs operations has enhanced cargo monitoring, reduced smuggling, and improved regulatory compliance (World Trade Organization, 2022). However, interoperability issues between international customs systems remain a major barrier, with 40% of customs agencies reporting integration difficulties (Narsalay & Omarjee, 2023). Countries that have successfully adopted standardized digital tracking systems have recorded a 25% improvement in trade transparency and operational efficiency (García-Menéndez & de Langen, 2022). International evidence confirms that electronic monitoring improves customs efficiency. In South Korea, Lee (2016) found that real-time cargo monitoring reduced clearance time from an average of four days to under two days, strengthening the country's logistics competitiveness. In Latin America, Chile successfully integrated electronic seals and tracking devices, resulting in improved revenue collection and enhanced compliance (World Bank, 2018). Conversely, Mexico's implementation was constrained by infrastructural challenges and user resistance, highlighting that technological adoption is highly context-dependent.

System features such as artificial intelligence (AI), blockchain, geofencing, and real-time notifications are revolutionizing customs operations. In European ports, AI-powered risk assessment tools have reduced assessment times by 65%, while blockchain-based cargo tracking in South Korea has minimized disputes by 80% (ECTS Advancements, 2024). These technologies enhance accuracy, security, and efficiency, leading to a 30% increase in customs compliance rates globally (Kim & Lee, 2023).

In Africa, the African Continental Free Trade Area (AfCFTA) has emphasized the importance of digital trade facilitation, with electronic tracking systems reducing cross-border delays by 28% (African Multidisciplinary Tax Journal, 2024). The East African Community (EAC) has implemented the Regional Electronic Cargo Tracking System (RECTS), leading to improved transit monitoring and increased customs revenue (Dongo & Rono, 2023). A study on East African trade corridors found that integrating ECTS with customs management systems reduced transit times by over 50% and prevented revenue losses worth USD 37 million annually (Wakuka, 2024). The World Bank (2020) logistics survey revealed that Rwanda's clearance times improved by almost 40 percent after deploying ECTS, largely due to reductions in the diversion of goods in transit. Uganda registered similar gains, particularly along the Northern Corridor. By contrast, Tanzania and Burundi have lagged, with the EAC Secretariat (2021) attributing this to weak ICT infrastructure and inconsistent enforcement frameworks. These findings suggest that regional adoption is uneven, and system effectiveness depends on national institutional capacities.

In Africa, real-time notifications in East African ECTS have reduced stakeholder response times by 70%, while geofencing has decreased route violations by 85% (Impact of RECTS on Key Stakeholders, 2023). Rwanda and Uganda have pioneered AI-driven risk profiling systems to improve trade monitoring (Wanjiru & Mutua, 2022).

In Kenya, the implementation of ECTS since 2013 has reduced transit cargo diversion by 76% and increased tax revenue by 18% (Kenya ICT Infrastructure, 2024). The Kenya Revenue Authority (KRA) has integrated ECTS with customs systems, improving cargo visibility and

expediting trade processes (Odhiambo & Wanyama, 2018). However, challenges such as intermittent internet connectivity continue to hinder real-time tracking (Lihanda & Kilonzi, 2020). The Kenya Transport and Logistics Network (2024) suggest that investing in 5G and fiber-optic connectivity could mitigate these challenges and enhance system reliability. The World Bank (2020) logistics survey revealed that Rwanda's clearance times improved by almost 40 percent after deploying ECTS, largely due to reductions in the diversion of goods in transit. Uganda registered similar gains, particularly along the Northern Corridor. By contrast, Tanzania and Burundi have lagged, with the EAC Secretariat (2021) attributing this to weak ICT infrastructure and inconsistent enforcement frameworks. These findings suggest that regional adoption is uneven, and system effectiveness depends on national institutional capacities.

The contrast between Kenya and leading economies like the U.S. highlights different stages in digital infrastructure maturity. For instance, the U.S. Customs and Border Protection (CBP) utilizes integrated electronic tracking and pre-arrival data systems to reduce clearance times. Kenya, in contrast, is still addressing basic connectivity issues. These comparisons suggest that while both aim to reduce delays, the emphasis in Kenya should remain on foundational improvements, particularly in expanding high-speed digital coverage to support ECTS functionality.

In Kenya, mobile accessibility has increased stakeholder engagement by 60% at ICD Nairobi, with enhanced dashboards improving decision-making by 40% (Electronic Cargo Tracking System and Operational Performance, 2015). However, underutilization of advanced ECTS features due to inadequate training remains a major issue (Gichuki & Kinyanjui, 2019). Addressing these barriers through capacity-building initiatives and improved system interoperability is crucial for optimizing ECTS effectiveness.

In addition, countries like Singapore have pioneered end-to-end cargo visibility systems incorporating AI and geofencing with real-time dashboards for customs and private logistics firms. Kenya's current implementation focuses on mobile access and dashboard usage, which is promising but underutilized in terms of potential. The progressive application of smart systems abroad underscores Kenya's opportunity to enhance ECTS functionality by integrating predictive and automated tools, enabling quicker and more informed decision-making.

2.3 Conceptual Framework

The conceptual framework presented in the figure below illustrates the relationship between the independent variables, technological infrastructure, system features, and the dependent variable, trade facilitation.

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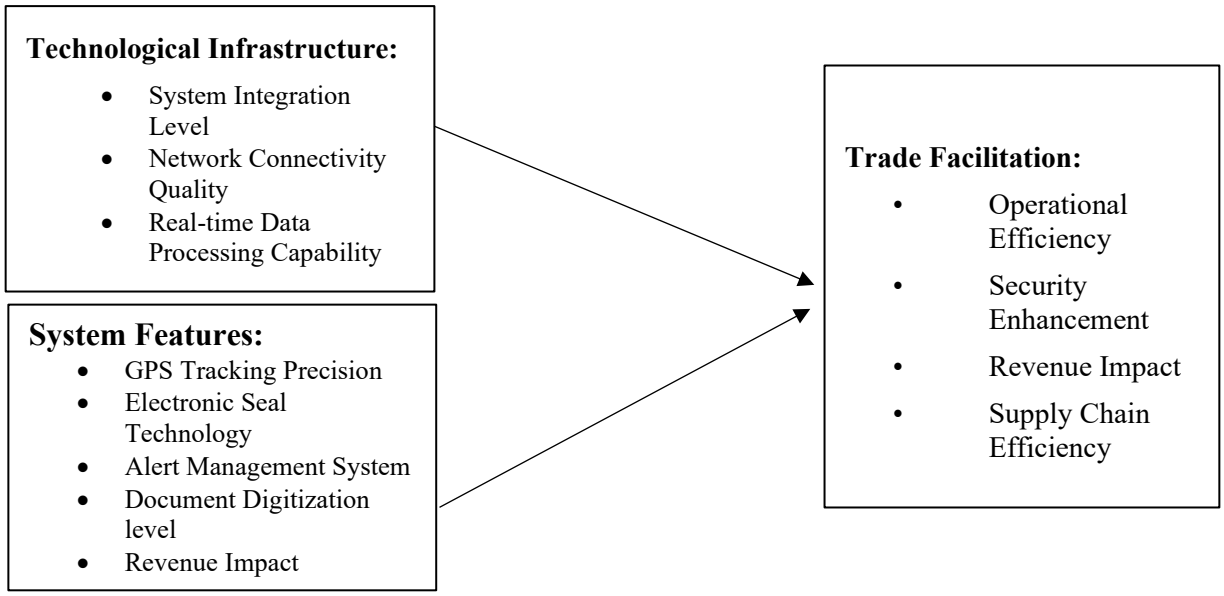

Figure 1: Conceptual Framework

3. Methodology

This study specifically adopted an explanatory cross-sectional survey design. Based on recent data, the population was estimated to be at 1,500 customs officials, 450 traders, and 150 logistics providers, totalling 2,100 individuals. These groups were chosen due to their direct involvement in ECTS operations, making their insights invaluable for assessing the system's effectiveness in enhancing trade facilitation. The choice of ICD Nairobi as the study site was purposive. As the largest inland clearance facility in Kenya, ICD Nairobi handles an average of 450,000 twenty-foot equivalent units (TEUs) annually (KPA, 2022). Its pivotal role in linking the Port of Mombasa to inland and regional markets makes it a microcosm of Kenya's customs modernization. Moreover, ICD Nairobi has been central to the rollout of the Regional Electronic Cargo Tracking System (RECTS), which means that insights from this location provide both national and regional relevance. Stratified sampling was used to sample 325 respondents. Descriptive statistics were used to summarize and describe the basic features of the dataset. Measures such as means, standard deviations, frequencies, and percentages were computed to provide a clear overview of respondents' profiles and their responses to questionnaire items. These statistics helped establish general trends regarding the implementation of ECTS at ICD Nairobi, including user experiences with system infrastructure, feature usage, training levels, and organizational readiness.

Descriptive data also aided in understanding the central tendencies and dispersion of responses for each variable, thus highlighting patterns such as common challenges in ECTS usage, levels of institutional support, and perceptions of trade facilitation outcomes. This offered contextual depth before inferential testing. These statistics not only summarized data but also helped in detecting anomalies, outliers, or patterns that could affect inferential tests. For example, frequency distributions revealed the proportion of respondents with more than five years of experience using ECTS, which contextualized perceptions of system maturity. To test the hypotheses and determine the statistical significance of relationships between variables, inferential statistical techniques will be applied. Specifically, Pearson correlation analysis was

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used to assess the strength and direction of the linear relationship between each independent variable—technological infrastructure, system features, human resource capacity, and organizational factors—and the dependent variable, trade facilitation. Following this, multiple linear regression analysis was performed to determine the combined and individual effects of the independent variables on trade facilitation. This method is appropriate for assessing causality and identifying which dimensions of ECTS implementation significantly predict improvements in trade facilitation outcomes.

4. Results and Discussion

4.1 Descriptive Analysis

This section provides the results of descriptive analysis, which were used to summarize the data, where such measures as percentages, means, and standard deviations were presented. The section is presented under subsections relating to the study variables.

4.1.1 Technological Infrastructure

This subsection presents a summary of the respondents' responses on their perception regarding technological infrastructure related to ECT implementation at ICD Nairobi. Based on the Likert scale used in the questionnaire, a mean of 2 and below indicated disagreement by the majority of the respondents, a mean of 3 means most were neutral, while a mean above 3 means the majority agreed with the statements.

Table 1: Descriptive Statistics for Technological Infrastructure

	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)	Mean	Std. Dev.
The level of system integration in ECTS is sufficient for trade facilitation	5.20	4.09	1.86	39.78	49.07	4.23	1.04
The network connectivity quality of ECTS ensures seamless operations	7.06	7.06	5.95	36.43	43.49	4.02	1.19
The system has a real-time data processing capability that enhances cargo monitoring	5.20	7.81	4.09	40.89	42.01	4.07	1.11
API integration in ECTS allows smooth data exchange with other systems.	4.46	2.60	2.97	45.72	44.24	4.23	0.96
Overall						**4.14**	**1.08**

The findings show that respondents strongly agreed that the level of system integration in ECTS is sufficient for trade facilitation, with a mean of 4.23 and a standard deviation of 1.04. The findings also showed that the majority of respondents agreed that the network connectivity quality of ECTS ensures seamless operations as relates with a mean of 4.02 and a low standard deviation of 1.19. Further, the majority agreed that the system has a real-time data processing capability that enhances cargo monitoring with a mean of 4.07 and a standard deviation of 1.11. Finally, the majority agreed that API integration in ECTS allows smooth data exchange with other systems, with a mean of 4.23 and a low standard deviation of 0.96. The overall mean and

standard deviation were 4.14 and 1.08, respectively, suggesting that most users find the ECTS system to be technologically sound and capable of supporting seamless trade operations.

4.1.2 System Features

The respondents were asked to rate their level of agreement on statements regarding system features based on a Likert scale of 1- strongly disagree, 2- disagree, 3-neutral, 4- agree, and 5- strongly agree. Based on this, a mean of 2 and below was interpreted to mean the majority of the respondents disagreed with a particular statement, and a mean above 3 was interpreted to mean the majority agreed. The same criteria were used to interpret the overall mean. An overall mean of 2 or less means that most of the respondents agreed with the majority of the statements, and a mean of 3 or above means the majority agreed with the majority of the statements. A summary of the study respondents' responses regarding system features is presented in Table 2.

Table 2: Descriptive Statistics for System Features

	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)	Mean	Std. Dev.
GPS tracking in ECTS provides accurate location monitoring	8.18	5.20	3.72	34.94	47.96	4.09	1.21
The electronic seal technology ensures cargo security	8.55	3.35	5.58	31.23	51.30	4.13	1.21
The alert management system is effective in responding to cargo violations	7.43	3.72	7.43	35.32	46.10	4.09	1.16
The system allows for efficient document digitization and accessibility	6.32	2.60	5.20	30.86	55.02	4.26	1.10
Overall						**4.14**	**1.17**

Based on the response provided majority of the respondents agreed that GPS tracking in ECTS provides accurate location monitoring, as the mean was 4.09 and the standard deviation was low at 1.21. The majority of the respondents also agreed that the electronic seal technology ensures cargo security with a mean of 4.13 and a low standard deviation of 1.21. The respondents also majorly agreed that the alert management system is effective in responding to cargo violations, with a mean was 4.09 and a standard deviation was 1.16. Finally, the majority of the respondents agreed that the system allows for efficient document digitization and accessibility (mean=4.26, standard deviation=1.10). The overall mean of 4.14 and standard deviation of 1.17 revealed that respondents generally agreed on the effectiveness of ECTS system features. This implies that system features such as GPS tracking, electronic seals, alert management, and document digitization are perceived as reliable and beneficial in improving cargo tracking and security.

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4.1.3 Trade Facilitation

The respondents were asked to rate their level of agreement on statements regarding trade facilitation based on a Likert scale of 1- strongly disagree, 2- disagree, 3-neutral, 4- agree, and 5- strongly agree. Based on this, a mean of 2 and below was interpreted to mean majority of the respondents disagreed with a particular statement, and a mean above 3 was interpreted to mean the majority agreed. The same criteria were used to interpret the overall mean. An overall mean of 2 or less means that most of the respondents agreed with the majority of the statements, and a mean of 3 or above means the majority agreed with the majority of the statements. The summary of the responses for the dependent variable trade facilitation is shown in Table 3.

Table 3: Descriptive Statistics for Trade Facilitation

	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)	Mean	Std. Dev.
The implementation of ECTS has led to improved operational efficiency	9.29	10.78	11.90	26.02	42.01	3.81	1.33
Cargo processing time has reduced due to ECTS	6.69	11.52	13.75	32.34	35.69	3.79	1.23
ECTS has enhanced the security of cargo in transit	10.04	7.81	10.78	27.14	44.24	3.88	1.33
The use of ECTS has improved revenue collection for regulatory authorities	6.69	7.43	13.75	29.00	43.12	3.94	1.21
The supply chain efficiency has increased as a result of ECTS	8.55	7.43	6.69	29.00	48.33	4.01	1.27
Overall						**3.89**	**1.28**

The statement that the implementation of ECTS has led to improved operational efficiency recorded a mean of 3.81 and a standard deviation of 1.33, suggesting that most respondents agreed. The mean score for the statement Cargo processing time has reduced due to ECTS was 3.79, with a standard deviation of 1.23, which implies general agreement. For the statement ECTS has enhanced the security of cargo in transit, the mean was 3.88, with a standard deviation of 1.33, indicating that respondents generally agreed. The statement that the use of ECTS has improved revenue collection for regulatory authorities recorded a mean of 3.94 and a standard deviation of 1.21, suggesting strong agreement. The highest-rated statement was that supply chain efficiency has increased as a result of ECTS, with a mean of 4.01 and a standard deviation of 1.27, which indicates strong agreement. The average of all mean scores was 3.89, and the standard deviation of 1.28, which shows moderate variation in responses, suggesting that while many shared similar views, a few respondents held differing opinions, but generally majority agreed.

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4.2 Correlation Analysis

Correlation was conducted in the study to assess the association between the independent variables and the dependent variable.

Table 4: Correlation Matrix

		Trade Facilitation	Technological Infrastructure	System Features
Trade Facilitation	Pearson Correlation			
	Sig. (2-tailed)			
	N	269		
Technological Infrastructure	Pearson Correlation	.568**		
	Sig. (2-tailed)	0.001		
	N	269	269	
System Features	Pearson Correlation	.593**	.157**	
	Sig. (2-tailed)	0.000	0.01	
	N	269	269	269

The correlation results indicate that the independent variable, technological infrastructure, has a moderate and statistically significant positive correlation with trade facilitation r=0.568, p=0.001). This means that improvement in technological infrastructure is associated with a corresponding improvement in trade facilitation. System features also have a moderate and statistically significant positive association with trade facilitation (r=0.593, p=0.000). This also implied that improved system features would be associated with improved trade facilitation.

4.3 Multiple Linear Regression Analysis

To determine the individual contribution of each independent variable to trade facilitation, a multiple linear regression analysis was conducted. The multiple linear regression analysis is used where there is one outcome variable and more than one predictor variable. In this study, four independent variables (technological infrastructure, system features) were included in the model.

Table 5: Coefficients of Regression

	Unstandardized Coefficients		**Standardized Coefficients**	**t**	**Sig.**
	B	**Std. Error**	**Beta**		
(Constant)	1.473	0.269		5.479	0.000
Technological Infrastructure	0.374	0.050	0.321	7.461	0.001
System Features	0.382	0.045	0.368	8.54	0.000

The findings showed that technological infrastructure has a positive and statistically significant effect on trade facilitation (β=0.374, p=0.001). This means that a one-unit increase in technological infrastructure leads to a 0.374-unit increase in trade facilitation. This implies that investment in robust technological infrastructure is essential in promoting efficient trade processes. These results are consistent with earlier studies that highlighted the function of technology infrastructure in facilitating trade. For example, the Digital Progress and Trends

Report (2023) states that within two years, strong digital systems can increase trade volumes by 15% and cut customs processing times by up to 50%. According to the World Trade Organization (2022), ECTS integration improves cargo surveillance, lowers smuggling, and increases compliance with customs procedures.

The findings also revealed that system features have a statistically significant positive effect on trade facilitation (β=0.382, p=0.000). This indicates that for every one-unit improvement in system features, trade facilitation improves by 0.382 units. This finding underscores the importance of enhancing the design and capabilities of systems like ECTS to boost trade outcomes. These findings align with previous studies. For example, according to ECTS Advancements (2024*)*, artificial intelligence (AI) and blockchain technologies have revolutionized customs operations in leading economies. In European ports, AI-powered risk assessment tools have cut assessment times by 65%, while blockchain-based cargo tracking in South Korea has reduced cargo disputes by 80%. These smart features have collectively led to a 30% global increase in customs compliance rates (Kim & Lee, 2023).

Estimated model

$Y = 1.473 + 0.374X1 + 0.382X2$

Where:

Y = Trade Facilitation

X1 = Technological Infrastructure

X2 = System Features

4.4 Hypotheses Testing

H01: Technological infrastructure has no significant effect on trade facilitation at ICD Nairobi.

This hypothesis tested whether the reliability, availability, and integration of digital infrastructure, such as GPS, internet connectivity, and system platforms, significantly influence the effectiveness of trade facilitation. A significant p-value (≤ 0.05) indicated that infrastructure plays a critical role in enabling efficient customs operations, such as reducing clearance delays and improving cargo visibility. In such a case, the null hypothesis was rejected, confirming that infrastructure improvements positively impact trade facilitation. If the p-value is greater than 0.05, the null hypothesis was not rejected, indicating that technological infrastructure does not significantly influence trade facilitation at ICD Nairobi.

H02: System features have no significant effect on trade facilitation at ICD Nairobi.

This hypothesis tested whether the reliability, availability, and integration of digital infrastructure, such as GPS, internet connectivity, and system platforms, significantly influence the effectiveness of trade facilitation. A significant p-value (≤ 0.05) indicated that infrastructure plays a critical role in enabling efficient customs operations, such as reducing clearance delays and improving cargo visibility. In such a case, the null hypothesis was rejected, confirming that infrastructure improvements positively impact trade facilitation. If the p-value is greater than 0.05, the null hypothesis was not rejected, indicating that technological infrastructure does not significantly influence trade facilitation at ICD Nairobi.

5. Conclusion

The study findings revealed that technological infrastructure has a positive and statistically significant effect on trade facilitation. Based on this, this study concludes that enhancing technological infrastructure, such as improved system integration level, network connectivity quality, real-time data processing capability, and API integration capabilities at Nairobi ICD, would improve trade. This implies that continuous investment in advanced technology-related infrastructure in the Nairobi ICD, such as by improving system integration, providing reliable network connectivity, improving real-time data productivity, and linking with other ICDs would enhance the efficiency in customs, reduce cargo clearance time and increase revenue, hence facilitating more trade. This aligns with literature that has established the importance of technological infrastructure in facilitating trade.

The study also observed that system features have a positive and statistically significant effect on trade facilitation. Based on this study's findings, the study concludes that enhanced system features by improving GPS tracking precision, electronic seal technology, alert management system, and document digitization level will increase trade facilitation. Enhancing these system features may lead to less fraud, improved transparency, and reduced delays, which may be caused by system malfunctions. Trade would hence be enhanced since the functionality of the system features improves.

6. Recommendations

Based on the above conclusions, the study suggests that ICD should strengthen its system integration and connectivity, enhance system features, provide continuous training, and improve organizational support, all of which would ensure improved trade facilitation. This can be achieved through investment in high-quality infrastructure, improving the GPS accuracy, allocating enough funds for training, and for system maintenance. The Nairobi ICD is recommended to upgrade the technological infrastructure by improving system integration, enhancing network reliability, so as to reduce downtime and clearance delays. The management of ICD should also prioritize the improvement in the system functionality by enhancing the GPS tracking system and the automated alert systems.

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