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Effect of Digital Technologies on Trade Facilitation at Nairobi's Customs Stations: Moderating Role of User Competence

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Abstract

Digital technologies are enhancing trade facilitation globally by streamlining customs operations, reducing costs, and boosting efficiency. This study aimed to fill this gap by evaluating the effects of key digital technologies on trade facilitation at Nairobi's customs stations: Inland Container Depot (ICD) Embakasi, Jomo Kenyatta International Airport (JKIA), and Wilson Airport. It assessed how the Single Window System (SWS), Non-Intrusive Inspection (NII), and Integrated Customs Management System (iCMS) affect trade facilitation and how user competence moderates this effect as a moderating factor. It assessed how the Single Window System (SWS), Non-Intrusive Inspection (NII), and Integrated Customs Management System (iCMS) affect trade facilitation and how user competence moderates this effect as a moderating factor. The study employed a quantitative design which was grounded in the Technology Acceptance Model, Diffusion of Innovations Theory, and Systems Thinking Theory. Structured questionnaires were administered to 350 respondents (clearing agents, customs officials, and logistics managers) selected through stratified random sampling. Findings indicated that SWS ($\beta = 0.411$, $p < 0.001$) and iCMS ($\beta = 0.427$, $p < 0.001$) had a significant positive effect on trade facilitation, explaining a substantial variance ($R^2 = 0.735$ in Model 2). NII showed moderate effects ($\beta = 0.139$, $p = 0.130$), approaching significance with interactions. The direct and moderating effect of user competence ($p > 0.05$) was not significant, likely due to training gaps. Moderation hypotheses were not rejected, but all main effect null hypotheses were. In conclusion, digital technologies enhance trade facilitation in Kenya, but their effectiveness is limited by issues of interoperability, infrastructure maintenance, and user skills. Recommendations include policy reforms for system integration, expanded training programs, and infrastructure investments to align with AfCFTA goals and global standards, ultimately improving Kenya's trade competitiveness.

Keywords: *Digital Technologies, Trade Facilitation, Customs Stations, User Competence, Single Window System, Non-Intrusive Inspection, Integrated Customs Management System, AfCFTA, Kenya*

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1. Introduction

The rapid advancement of digital technologies has revolutionized global trade facilitation by enhancing efficiency, reducing costs, and improving transparency in customs clearance procedures (World Trade Organization, 2025). "Developed economies have widely adopted digital customs systems such as Single Window platforms, automated scanning technologies, and Integrated Customs Management Systems (iCMS), significantly reduced cargo clearance times and minimizing human intervention. For instance, the European Union's digital customs solutions have reduced trade processing times by 40%, while Singapore's TradeNet system processes 90% of customs declarations within 10 minutes (Duval, Utoktham, & Kravchenko, 2018). The technologies have also eliminated the leakages of revenues, with the World Customs Organization (2021) stating that customs fraud decreased by 30 percent in countries whose systems are completely automated. All these notwithstanding, there remain differences between the developed and the developing countries in the facilitation of digital trade. According to the World Bank (2020), manual custom procedures escalate trade by 15-30 percent with low-income economies suffering most as a result. Even though there have been improvements in the average dwell times of cargo (under 24 hours, in advanced economies) using digital Single Window Systems (SWS), numerous developing territories continue using paper-based systems, thus retaining the excessive dwell times (Budimirovic et al., 2021). It is against this global divide that scalable and adaptable digital solutions should be able to cut gaps in efficiency in international trade.

In Africa, the adoption of digital trade facilitation technologies remains uneven, with many countries still grappling with bureaucratic inefficiencies and high trade costs (Kere & Zongo, 2023). The African Continental Free Trade Area (AfCFTA) has identified digital customs modernization as a key enabler of intra-African trade, yet only 30% of African countries have fully implemented Single Window Systems (Abrahams et al., 2023). Manual customs processes contribute to an average cargo clearance time of 5–10 days, compared to 1–2 days in digitally advanced regions (Wonyra &Tenakoua, 2021). These inefficiencies inflate trade costs by up to 25%, undermining Africa's competitiveness in global markets. The digital trade facilitation has become popular in the East African Community (EAC), but enforcement varies across the member states. In the field of customs automation, Rwanda is ahead of the pack as the country was expected to collect 20 per cent more revenues and had cut down clearance time by 40 per cent through their iCMS (EAC Trade Report 2023). Single Window System in Tanzania has also enhanced efficiency with dwell time in Dar es Salaam port in Tanzania reduced by 7 days to 3 days (EAC, 2022). Uganda and Burundi, however, fall behind, and there are still more than 60 percent manual systems of customs, leading to delays in borders and the increased costs of trade (EAC Secretariat, 2023). The fight against transit fraud was increased by 15 percent, thanks to the encouragement of regional integration processes, including the EAC Electronic Cargo Tracking System (ECTS) (EAC, 2023).

Nevertheless, it has interoperability issues yet to be solved with just 50 percent of Single Window Systems at EAC member states connected to each other completely. Research done in 2023 established that fragmented digital systems increase the cross-border transactions across the region by 2-3 days in cross-border trade (EAC Trade Report, 2023). There is a need to harmonize digital practices frameworks in the EAC in order to provide ease of regional trade. Some of the challenges that could inhibit the process of digitalising the customs activities include poor infrastructure, poor interoperability and change resistance. A study conducted in

2024 revealed that only 40 percent of customs administrations in Africa have deployed risk-based scanning technology and this has resulted in patchiness in the inspection of cargo (Kouty, 2024). Moreover, online insecurity and system shutdown make digital platforms less effective, as 35 percent of customs agencies said that they had experienced data breaches within the last five years (Abrahams et al., 2023). These shortcomings are crucial to deal with to make Africa maximize the potential of digital trade facilitation in AfCFTA. Kenya, as East Africa's largest trade hub, has made significant strides in digitizing customs operations at key entry points, including the Inland Container Depot (ICD), Jomo Kenyatta International Airport (JKIA), and Wilson Airport. The Kenya National Electronic Single Window System (KNESWS) has reduced cargo dwell time at the port of Mombasa by 30%, while the Integrated Customs Management System (iCMS) has increased revenue collection by 25% through reduced fraudulent declarations (KRA, 2023). However, inefficiencies persist due to system interoperability gaps, low stakeholder awareness, and inconsistent enforcement (Nganga, 2021).

1.1 Problem Statement

Trade facilitation at customs stations in Nairobi including the Inland Container Depot (ICD), Jomo Kenyatta International Airport (JKIA), and Wilson Airport faces persistent inefficiencies due to reliance on outdated manual processes. Despite the global shift toward digitalization, these stations continue to grapple with delays, excessive paperwork, and inconsistent enforcement, which increase the cost of doing business and undermine Kenya's competitiveness in regional trade (World Bank, 2021). For instance, cargo clearance at the ICD takes an average of 7–10 days, compared to 1–2 days in advanced economies with fully digitized customs systems (UNCTAD, 2022). Such delays result in significant demurrage costs, with importers incurring up to KES 50,000 per day for stranded containers (Kenya Trade Network Agency, 2023). These inefficiencies not only raise operational expenses for traders but also discourage foreign investment, limiting Kenya's potential as a logistics hub for East Africa. The adoption of Single Window Technology could streamline trade documentation by consolidating submissions from multiple agencies into a single platform. However, Nairobi's customs stations still lack full interoperability between systems, forcing traders to submit duplicate documents to customs, port authorities, and regulatory agencies (KRA, 2022). A 2023 study by the Kenya National Bureau of Statistics found that 65% of importers manually submit documents to at least three agencies, increasing processing times by 30% (KNBS, 2023). Without seamless data sharing, the Single Window's potential to reduce clearance times and enhance transparency remains unrealized. Additionally, low awareness among small-scale traders about the technology's benefits further hampers adoption, perpetuating reliance on inefficient paper-based processes.

Non-Intrusive Inspection has been introduced at JKIA and ICD to accelerate cargo inspections and reduce physical checks, yet operational gaps persist. While high-risk shipments require scanning, only 40% of cargo undergoes non-intrusive inspection due to equipment shortages and maintenance lapses (KRA Annual Report, 2022). This inconsistency creates bottlenecks, as unscanned cargo must wait for manual inspections, delaying release by up to 48 hours (TradeMark East Africa, 2023). Moreover, scanner breakdowns occur frequently, with 25% of devices at JKIA reported as non-functional in 2023, forcing customs to revert to slower manual methods (Kenya Airports Authority, 2023). Such inefficiencies undermine the technology's role in trade facilitation, increasing storage costs and supply chain disruptions for businesses.

The Integrated Customs Management System (iCMS) was implemented to enhance efficiency through automation, but challenges in system integration and stakeholder resistance limit its impact. Although iCMS reduced average clearance times by 20% in its pilot phase, frequent downtimes and a lack of training for customs officers have led to inconsistent usage (Lihanda & Kilonzi, 2022). A 2023 audit revealed that 35% of iCMS transactions at ICD were later manually overridden due to errors, negating time-saving benefits (KRA Internal Audit, 2023). Additionally, traders cite difficulties in navigating the system, with 50% relying on intermediaries to lodge declarations, which increases compliance costs (KNBS, 2023).

Without addressing these technical and capacity gaps, digital technologies will fail to deliver the anticipated improvements in trade facilitation, leaving Nairobi's customs stations lagging behind global benchmarks. The persistence of these inefficiencies highlights an urgent need to evaluate how effectively Single Window Technology, Non-Intrusive Inspection, and iCMS enhance trade facilitation at Nairobi's key customs stations. This study shall present workable recommendations to streamline these technologies, slow down the clearance periods, and drive down trade expenses, all of which is needed to enhance Kenya as the trade hub in the region. Facilitation of trade at the customs stations of Nairobi including Inland Container Depot (ICD) and Jomo Kenyatta International Airport (JKIA) and Wilson Airport has remained inefficient with some degree of inefficiency as a result of both systemic characteristics and user-related factors. In spite of the use of digital technologies, there are still systemic problems like the lack of interoperability in the Single Window System (SWS), where 65 percent of

importers make duplicates of documents, because the systems are disjointed behind the scenes (KNBS, 2023), and frequent re-occurring downtimes in Non-Intrusive Inspection (NII) scanners (one-fourth fail to operate at JKIA) delay the clearance process by up to 48 hours (Kenya Airports Authority, 202 At the same time, the problems that affect the users (low digital literacy among small scale traders (50 percent of traders depend on middlemen in submitting iCMS) or poor training of the custom officers (40 percent do not have advanced skills in using the scanners) contribute to these inefficiencies, raising the costs of compliance by 20 percent (KNBS, 2023;Kipchilat, 2023). These dual challenges inflate trade costs, with importers incurring up to KES 50,000 per day in demurrage fees (Kenya Trade Network Agency, 2023), undermining Kenya's competitiveness under the African Continental Free Trade Area (AfCFTA). The purpose of the study is to assess the degree of systemic factors, as well as user incompetence that may induce these inefficacies, as well as propose actionable recommendations to maximize the facilitation of digital trade.

1.2 Specific Objectives

i. To evaluate the effect of the Single Window System on trade facilitation at customs stations in Nairobi, Kenya.

ii. To examine the impact of Non-Intrusive Inspection on trade facilitation at customs stations in Nairobi, Kenya.

iii. To investigate the effect of the Integrated Customs Management System (iCMS) on trade facilitation at customs stations in Nairobi, Kenya.

iv. a) To examine the moderating effect of user competence on the relationship between the Single Window System and trade facilitation at Nairobi customs stations in Kenya.

b) To investigate the moderating effect of user competence on the relationship between Non-Intrusive Inspection and trade facilitation at Nairobi customs stations in Kenya.

c) To investigate the moderating effect of user competence on the relationship between the Integrated Customs Management System (iCMS) and trade facilitation at Nairobi customs stations in Kenya.

2. Literature Review

2.1 Theoretical Review

2.1.1 Technology Acceptance Model (TAM)

Davis (1989) developed the Technology Acceptance Model (TAM) to explain user adoption of new technologies based on perceived usefulness and ease of use. In customs digitalization, TAM suggests that customs officials, clearing agents, and traders will adopt digital systems if they perceive them as beneficial and user-friendly (Davis, 1989). Resistance often stems from perceived complexity and inadequate training (Lihanda & Kilonzi, 2022). Kenya's Integrated Customs Management System (iCMS) initially faced technical challenges and limited stakeholder engagement (KRA Annual Report, 2023), highlighting the need for ongoing training and intuitive interfaces to boost adoption. Akbari and Hopkins (2022) support this, noting that digital customs solutions are more readily adopted when they reduce workload and enhance efficiency. However, low digital literacy among small-scale traders in Nairobi's customs stations has impeded the Single Window System's benefits, leading to persistent manual submissions and inefficiencies. TAM also emphasizes organizational support in regulated customs environments, where investments in training and infrastructure drive successful implementation (Chen, 2019). At JKIA, Non-Intrusive Inspection (NII) scanners initially met resistance from officers accustomed to manual methods (Kipchilat, 2023), but targeted training revealed efficiency gains from fewer physical inspections, increasing acceptance. This aligns with TAM's focus on perceived usefulness and ease of use as key adoption factors. Thus, policymakers must prioritize user education and system usability to overcome resistance and improve compliance in Nairobi's customs stations.

2.1.2 Diffusion of Innovations Theory

Rogers (2003) Diffusion of Innovations Theory describes how technologies spread through societies, categorizing adopters as innovators, early adopters, early majority, late majority, and laggards based on their openness to change. In Kenya, early adopters like large logistics firms benefit from faster clearances, while laggards such as small traders resist due to unfamiliarity (Nganga, 2021). The theory advocates awareness campaigns and pilot programs to accelerate diffusion. Kenya's phased rollout of the Single Window System (SWS) targeted high-volume importers before extending to smaller traders, facilitating smoother transitions (KRA, 2022). The theory also stresses communication channels for uptake. Moldabekova et al. (2021) found that stakeholder engagement via workshops and feedback boosts adoption. At ICD Embakasi, iCMS sensitization programs increased digital declarations by 25% in the first year (KRA Annual Report, 2023). Challenges persist with laggard groups like informal traders reliant on intermediaries. Leveraging opinion leaders, such as industry associations, can demonstrate benefits. Slow adoption of scanning at Wilson Airport, with only 40% of cargo scanned non-intrusively, highlights the need for targeted strategies to ensure stakeholders value digital transformation (Kenya Airports Authority, 2023).

2.1.3 Rational Expectations Theory

Rational Expectations Theory (Lucas, 1972) posits that decisions are based on anticipated costs and benefits. In digital customs, stakeholders evaluate efficiency gains against challenges (Akbari & Hopkins, 2022). Automated scanning reduces times but faces high maintenance costs (TradeMark East Africa, 2023). The theory recommends demonstrating clear advantages to promote adoption. In Nairobi, iCMS's initial investment was justified by revenue increases from reduced fraud and faster processing (Lihanda & Kilonzi, 2022), though downtimes have eroded trust (KRA Internal Audit, 2023). The theory explains trader skepticism despite proven benefits. Dere (2021) noted SMEs at JKIA hesitate due to hidden costs like software fees. To address this, KRA offered discounted training and fee exemptions, spurring tentative adoption (KNBS, 2023). The theory underscores balancing economic incentives and risk perceptions to foster technology adoption in trade facilitation, urging policies to minimize financial and operational barriers.

2.1.4 Systems Thinking Theory

Systems Thinking Theory (Senge, 1990) offers a holistic view of how technology, processes, and human factors interact to shape outcomes (Senge & Sterman, 1990). In digital trade facilitation, the efficacy of SWS, NII, and iCMS relies on usability, training, and feedback. Despite iCMS's features, downtimes and poor UX have led to manual overrides (KRA Internal Audit, 2023). The theory stresses aligning tools with user competencies, addressing interoperability, and promoting adaptive learning (Checkland, 1999; Sterman, 2000). Policymakers can thus ensure technical advancements yield efficiency gains by integrating user experience as a moderator between digital technologies and trade outcomes.

2.2 Empirical Review

2.2.1 Single Window System and Trade Facilitation

The Single Window System (SWS) streamlines trade by allowing unified electronic document submissions, reducing redundancies and clearance times. In Singapore, TradeNet processes 90% of declarations in 10 minutes via integrated agencies (Duval et al., 2018). The EU's UCC cut cargo dwell times by 40% with harmonized digital declarations (WTO, 2021). In Kenya, KNESWS faces interoperability issues, with 65% of importers submitting duplicates due to uncoordinated backend systems among KRA, KPA, and others (KNBS, 2023). This results in 7–10-day clearances at ICD Nairobi, versus 24 hours in Rotterdam (UNCTAD, 2022). Low adoption among SMEs, with only 30% at JKIA fully using KNESWS due to complexity and costs (TradeMark Africa, 2023), aligns with World Bank (2022) findings on user competence. Rwanda's SWS reached 80% adoption via sensitization and subsidies (EAC Trade Report, 2023), while Kenya's top-down approach increased SME costs by 20% (KNBS, 2023). Cybersecurity breaches (15 in 2023) erode trust (KRA Internal Audit, 2023). Ghana's GCNet halved times with mandatory digital submissions (WCO, 2021), contrasting Kenya's 60% digital rate (KRA, 2023). AfCFTA (2023) notes SWS interoperability could cut intra-African costs by 15%. Addressing integration, education, and security could align Kenya with global standards, enhancing transparency and reducing corruption.

2.2.2 Non-Intrusive Inspection and Trade Facilitation

Non-Intrusive Inspection (NII) technologies like X-ray scanners enable rapid, non-contact cargo checks, boosting security and reducing delays. Rotterdam processes 98% of cargo in 2

hours with low false alarms (WCO, 2021). Dubai's AI scanners cut times from 4 hours to 30 minutes and raised detection by 35% (World Bank, 2022). In Kenya, NII at JKIA and ICD Embakasi suffers from 25% downtime due to maintenance, leading to 48-hour delays via manual checks (KAA, 2023; TradeMark Africa, 2023). Only 40% of JKIA cargo is digitally inspected, versus 85% in Singapore (KRA Annual Report, 2023). Kenya's selective scanning bypasses 30% of high-risk shipments due to shortages (KRA Internal Audit, 2022), causing $300 million annual losses (UNODC, 2023). South Africa's SARS achieves 90% compliance with risk systems (WCO, 2021). User competence issues, with 40% of officers untrained in image interpretation (Kipchilat, 2023), mirror Tanzania's 50% utilization gains post-training (EAC, 2023). Disjointed agency communication duplicates inspections (KNBS, 2023). Rwanda's centralized center reduced redundancies by 60% (EAC Trade Report, 2023). Integrated approaches, training, and maintenance could optimize NII in Nairobi, aligning with global practices and mitigating risks.

2.2.3 Integrated Customs Management System (iCMS) and Trade Facilitation

The Integrated Customs Management System (iCMS) unifies customs operations, automating declarations, assessments, and tracking to enhance efficiency and revenue (Lihanda & Kilonzi, 2022). In Kenya, iCMS boosted revenue by 25% via reduced fraud and compliance (KRA Annual Report, 2023). Integration with KNESWS enables electronic lodging and feedback, cutting dwell times at ICD and JKIA (Dere, 2021). Challenges include 35% manual overrides from errors or unfamiliarity (KRA Internal Audit, 2023), plus IT vulnerabilities causing downtime (Malatji, 2023). 50% of traders rely on intermediaries, raising costs (KNBS, 2023). South Africa's ASYCUDA cut times by 40% with automation (WCO, 2021); Rwanda's iCMS reduced corruption by 30% via data sharing (World Bank, 2022). Kenya should address gaps through scalable IT, partnerships, and training to ensure widespread adoption (Akbari & Hopkins, 2022).

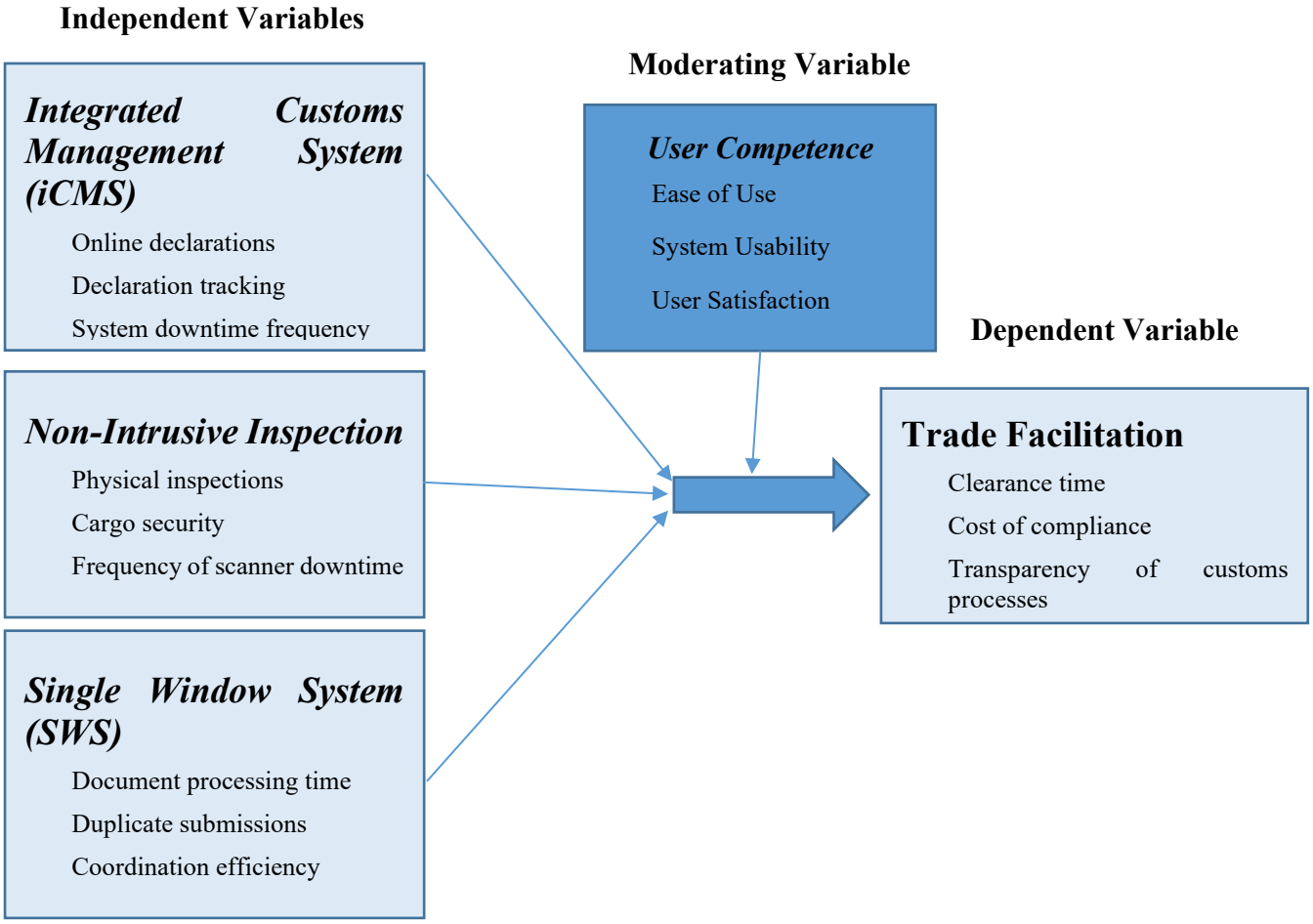
2.2.4 User Competence Moderating Digital Technologies and Trade Facilitation

User competence moderates digital technologies' success in trade facilitation. Kipchilat (2023) found JKIA scanning efficiency varies with officer skills, with trained staff improving inspections by 40% while untrained revert to manuals, delaying by 48 hours. Rwanda's iCMS training raised utilization by 60%, reducing times and boosting compliance (World Bank, 2022). In Nairobi, low trader literacy leads to intermediary reliance, increasing costs by 20% (KNBS, 2023), aligning with TAM (Davis, 1989). For KNESWS, 50% of SMEs submit paper documents due to unfamiliarity, negating 30%-time reductions (KNBS, 2023; KRA, 2022). Large firms see 25% gains with trained staff. Singapore's mandatory certifications ensure 95% error-free declarations (UNCTAD, 2022), versus Kenya's 40% participation (TradeMark Africa, 2023). Malaysia cut overrides from 35% to 5% with ongoing training (WCO, 2021). In Kenya, 30% declaration errors and breaches stem from inadequate courses (KRA Internal Audit, 2023; Malatji, 2023). Institutionalizing certifications, simulations, and campaigns could raise compliance by 70%, as in South Africa (WCO, 2021), making competence essential for sustainable facilitation. 2.3 Conceptual Framework The conceptual framework illustrates the relationship between digital technologies (independent variables) and trade facilitation (dependent variable). Independent variables include Single Window System (SWS), measured by reduced processing times, eliminated duplicates, and improved coordination (UNCTAD, 2022); Non-Intrusive Inspection, assessed via reduced physical inspections, enhanced security,

and downtime frequency (Wandera, 2020); and Integrated Customs Management System (iCMS), evaluated through automated declarations, real-time tracking, and system uptime (Lihanda & Kilonzi, 2022). Trade facilitation is operationalized by clearance times, compliance costs, and process transparency (OECD, 2021). Effective implementation of these technologies is posited to yield faster clearances, lower costs, and greater accountability at Nairobi's customs stations.

2.3 Conceptual Framework

The conceptual framework illustrates the relationship between digital technologies (independent variables) and trade facilitation (dependent variable), with user competence serving as a moderating factor, as shown in Figure 1:



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3. Methodology

The study adopted a quantitative approach, utilizing structured survey questionnaires to collect data from clearing agents, customs officials, and logistics managers. The methodology ensured reliability, validity, and ethical compliance, while the data analysis employed descriptive and inferential statistics, including multiple regression analysis, to test the study's hypotheses. The target population for this study comprised clearing agents, customs officials, and logistics managers operating at ICD Embakasi, JKIA, and Wilson Airport. The sample size of 311 respondents was determined using Yamane's formula (1967), ensuring a 95% confidence level and a 5% margin of error. This approach guaranteed statistical robustness while accounting for potential non-response bias. The study employed stratified random sampling to ensure representation across key stakeholder groups at Nairobi's customs stations: clearing agents, customs officials, and logistics managers. The sample size is determined using Yamane's (1967) formula to ensure sufficient representation across the four strata: clearing agents (100), customs officials (100), logistics managers (120), and transporters (50).

The collected data were analyzed using descriptive and inferential statistics with SPSS Version 27. Descriptive statistics (mean, standard deviation, frequencies) summarized respondent demographics and variable trends. Inferential statistics included Pearson's correlation analysis to examine relationships and hierarchical regression analysis to test the study's hypotheses, including the moderating effect of user competence.

The hierarchical regression model followed three steps to test moderation (Cohen et al., 2003):

1. **Direct Effects Model**: Tested the effect of independent variables (Single Window System, Non-Intrusive Inspection, iCMS) on trade facilitation, controlling for extraneous variables (e.g., firm size, trade volume):

   $TF = \beta_0 + \beta_1 SWS + \beta_2 NII + \beta_3 iCMS + \beta_4 CV + \varepsilon$

2. **Moderator Model**: **Added** user competence (UC) to **assess** its direct effect:

   $TF = \beta_0 + \beta_1 SWS + \beta_2 NII + \beta_3 iCMS + \beta_4 UC + \beta_5 CV + \varepsilon$

3. **Interaction Model:** Included interaction terms to test moderation:

   $TF = \beta_0 + \beta_1 SWS + \beta_2 NII + \beta_3 iCMS + \beta_4 UC + \beta_5 (SWS \times UC) + \beta_6 (NII \times UC) + \beta_7 (iCMS \times UC) + \beta_8 CV + \varepsilon$

4. Results and Discussion

4.1 Descriptive Statistics

The following section shows the descriptive statistics of study variables. Descriptive analysis summarized the central tendencies, dispersion, and distribution of the data, to form the basis of inferential tests. It was useful in pointing out patterns, e.g., skewness or outliers, that may have affected the interpretation of the impact of digital technologies.

4.1.1 Descriptive Results for Single Window System (SWS)

The first objective of the study was to determine the effects of SWS on trade facilitation in the Kenyan trade sector. Participants of the research were supposed to indicate their agreement with statements provided concerning SWS practice in their organization. This was done on an ordinal scale ranging from one (1) to five (5). The lowest value of 1 indicated strong disagreement, while the highest possible value of 5 indicated strong agreement. A neutral stand was represented by (3). The perspectives in means and SD are as indicated in Table 4. The average SWS was equal to 2.964, and the standard deviation was equal to 0.7053 (variance = 0.497, minimum = 1.0, maximum = 4.6). This average value implied consensus in the general sense, but the standard deviation showed that perceptions varied, potentially because of usability problems between various stakeholders. The variety of opinions, including low contentment and high contentment, should have been analyzed further in regression.

4.1.2 Descriptive Results for Non-Intrusive Inspection (NII)

The second objective of the study was to determine the effects of NII on the trade facilitation in the Kenyan trade sector. Participants of the research were supposed to indicate their agreement with statements provided concerning NII practice in their organization. This was done on an ordinal scale ranging from one (1) to five (5). The lowest value of 1 indicated strong disagreement, while the highest possible value of 5 indicated strong agreement. A neutral stand was represented by (3). The perspectives in means and SD are as indicated in Table 4. The average score of NII was 2.975 and the standard deviation of NII was 0.6842 (variance=0.468, minimum=1.2, maximum=4.8). The marginally greater mean suggested positive attitudes towards efficiency, and the reduced variation indicated that there was more agreement. This may have indicated that NII was non-disruptive, which was helpful to transporters, but the lowest score indicated that implementation may have been difficult.

4.1.3 Descriptive Results for Integrated Customs Management System (iCMS)

The third objective of the study was to establish the impact of iCMS on facilitation of trade in the Kenyan trade sector. Participants of the research were supposed to indicate their agreement with statements provided concerning iCMS practice in their organization. This was done on an ordinal scale ranging from one (1) to five (5). The lowest value of 1 indicated strong disagreement, while the highest possible value of 5 indicated strong agreement. A neutral stand was represented by (3). The perspectives in means and SD are as indicated in Table 4. The iCMS means was 2.985 and SD=0.6910 (variance=0.477, minimum=1.4 maximum=4.8). High mean of technologies revealed high perceived value of integration, but there was some dispersion which could have been due to clearing agents experiencing technical glitches.

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4.1.4 Descriptive Results for User Competency.

The fourth objective of the study was to examine how User Competency would moderate the relationship between digital technologies and trade facilitation. Participants of the research were supposed to indicate their agreement with statements provided concerning User Competency in their organization. This was done on an ordinal scale ranging from one (1) to five (5). The lowest value of 1 indicated strong disagreement, while the highest possible value of 5 indicated strong agreement. A neutral stand was represented by (3). The perspectives in means, SD, and distribution are as indicated in Table 4. The average score on User Competency was 2.918095238 with the standard deviation 0.761386779853081 (variance = 0.580, minimum = 1.0, maximum = 5.0). Distribution: 19 percent low, 65 percent moderate, 16 percent high competency. The average indicated average skills and greater variability indicated training gaps. The distribution showed that the greatest frequency was in the middle ranges and suggested a possibility of moderation effects in regression.

4.1.5 Descriptive Results for Trade Facilitation

The dependent variable of the study was Trade Facilitation. Participants of the research were supposed to indicate their agreement with statements provided concerning Trade Facilitation in their organization. This was done on an ordinal scale ranging from one (1) to five (5). The lowest value of 1 indicated strong disagreement, while the highest possible value of 5 indicated strong agreement. A neutral stand was represented by (3). The perspectives in means, SD, and distribution are as indicated in Table 4. The average score of Trade Facilitation was 2.947 and had a standard deviation of 0.6854 (variance = 0.470, minimum = 1.4, maximum = 4.6). Distribution: According to frequency information, it had a score of about 42 within the score range of 2.6 and 3.4, 12.6 under the score range of 2.0 and 6.3 above the score range of 4.0 (calculations done using cumulative percentages). This meant that there was moderate overall facilitation, which could have been improved by using digital tools, since variability represented an uneven experience among stakeholders.

Table 1: Descriptive Statistics for SWS, NII, iCMS, User Competence, & Trade Facilitations

Variables	N	Minimum	Maximum	Mean	Std. Deviation	Variance
SWS	350	1.0	4.6	2.964	.7053	.497
NII	350	1.2	4.8	2.975	.6842	.468
iCMS	350	1.4	4.8	2.985	.6910	.477
User_Competency	350	1.00	5.00	2.9184	.7614	.580
Trade Facilitation	350	1.4	4.6	2.947	.6854	.470
Valid N (listwise)	350					

4.2 Correlation Analysis

Pearson correlation coefficients were used to analyse the relationship of the independent variables (SWS, NII, iCMS, User Competency) and the dependent variable (Trade Facilitation). There were significant positive correlations between all variables and Trade Facilitation at the 0.01 level (2-tailed) with correlation coefficients of 0.655-0.801 (based on hierarchical regression zero-order correlations). As well, Trade Facilitation vs Predicted Trade Facilitation was 0.826 ($p < 0.01$) which proved the regression model. Such correlations

indicated a strong correlation, but multicollinearity tests were required in order to prevent spurious conclusions in regression.

Table 2: Correlation Matrix

Variables		SWS	NII	iCMS	User Competency	Trade Facilitation
SWS	Pearson Correlation	1	.744**	.726**	.699**	.763**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	350	350	350	350	350
NII	Pearson Correlation	.744**	1	.713**	.690**	.713**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	350	350	350	350	350
iCMS	Pearson Correlation	.726**	.713**	1	.645**	.734**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	350	350	350	350	350
User_Competency	Pearson Correlation	.699**	.690**	.645**	1	.690**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	350	350	350	350	350
Trade Facilitation	Pearson Correlation	.763**	.713**	.734**	.690**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	350	350	350	350	350

**. Correlation is significant at the 0.01 level (2-tailed).

4.3 Regression Analysis

The hierarchical multiple regression was used to determine the effect of the demographic variables, digital technologies, and User Competency, and the terms of their interaction on Trade Facilitation. The last model (Model 4) represented the best model that explained the Trade Facilitation ($R^2 = 0.789$, Adjusted $R^2 = 0.752$), and the F-statistic of the model was 20.960 ($p = 0.001$), which showed a significant fit. The value of Durbin-Watson (=1.728) indicated that there was no autocorrelation. Significant changes were noted in the R^2: 3.0 percent due to demographics (non-significant), 73.5 percent due to digital technologies (significant), 0.7 percent due to User Competency (non-significant), and 1.8 percent due to interaction terms (non-significant). High VIF in interactions implied the existence of multicollinearity, although main effects could still be interpreted.

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Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					
					R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.172[a]	.030	-.016	.7278	.030	.643	3	63	.590	
2	.874[b]	.764	.741	.3676	.735	62.332	3	60	.000	
3	.878[c]	.771	.744	.3653	.007	1.747	1	59	.191	
4	.888[d]	.789	.752	.3598	.018	1.601	3	56	.199	1.728

Analysis of Variance (ANOVA) was used to determine the overall significance of the regression models. In case of Model 1, ANOVA was not significant ($F = 0.643$, $p = 0.590$). Model 2 was important (significant) ($F = 32.427$, $p < 0.001$), which means that digital technologies were meaningful (contributed significantly) to the model. Model 3 and Model 4 were also significant ($F = 28.390$, $p < 0.001$ and $F = 20.960$, $p < 0.001$ respectively) although the inclusion of interactions did not help (improve) the model significantly.

Table 4: Analysis of Variance

Model		Sum of Squares	DF	Mean Square	F	Sig.
1	Regression	1.022	3	.341	.643	.590[b]
	Residual	33.368	63	.530		
	Total	34.390	66			
2	Regression	26.285	6	4.381	32.427	.000[c]
	Residual	8.106	60	.135		
	Total	34.390	66			
3	Regression	26.518	7	3.788	28.390	.000[d]
	Residual	7.873	59	.133		
	Total	34.390	66			
4	Regression	27.140	10	2.714	20.960	.000[e]
	Residual	7.251	56	.129		
	Total	34.390	66			

The ANOVA results indicated that Model 1 was not significant ($F = 0.643$, $p = 0.590$), suggesting demographics alone did not explain Trade Facilitation. Model 2 was highly significant ($F = 32.427$, $p < 0.001$), showing that digital technologies added substantial explanatory power. Model 3 remained significant ($F = 28.390$, $p < 0.001$), though the addition of User Competency did not improve significance. Model 4 was significant ($F = 20.960$, $p < 0.001$), confirming the full model's fit, despite non-significant interactions.

The coefficients showed that SWS ($\beta = 0.411$, $t = 3.979$, $p = 0.001$) and iCMS ($\beta = 0.427$, $t = 4.505$, $p = 0.001$) were significant positive predictors in Model 2, but NII was not ($\beta = 0.139$, $t = 1.534$, $p = 0.130$). User Competency did not matter (was not significant) in Model 3 ($\beta = 0.119$, $t = 1.322$, $p = 0.191$). Interactions led to changes in Model 4 where NII approached significance ($\beta = 0.859$, $t = 1.925$, $p = 0.059$), however, there is (was) no significant interaction.

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Table 5: Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
2 (Constant)	-.079	.397		-.198	.843					
SWS	.421	.106	.411	3.979	.000	.801	.457	.249	.369	2.711
NII	.155	.101	.139	1.534	.130	.681	.194	.096	.480	2.084
iCMS	.443	.098	.427	4.505	.000	.791	.503	.282	.437	2.289

The coefficients revealed that in Model 2, SWS ($\beta = 0.411$, $t = 3.979$, $p < 0.001$) and iCMS ($\beta = 0.427$, $t = 4.505$, $p < 0.001$) were significant positive predictors, while NII was not ($\beta = 0.139$, $t = 1.534$, $p = 0.130$). In Model 3, User Competency was non-significant ($\beta = 0.119$, $t = 1.322$, $p = 0.191$). Model 4 showed shifts due to interactions, with NII nearing significance ($\beta = 0.859$, $t = 1.925$, $p = 0.059$), but interactions remained non-significant.

4.4 Test of Hypotheses

The purpose of the study was to examine how User Competency would moderate the relationship between digital technologies and trade facilitation. This informed the fourth null hypothesis of the research. The fourth test was H04: The relationship between digital technologies and Trade Facilitation was not mediated by User Competency. Table 4.15 shows that under the same condition, at 0.05 confidence level, the interaction terms did not significantly predict Trade Facilitation, NII as a User, iCMS as a User in Model 4 (SWS_User $\beta = 1.749$, $p = 0.131 > 0.05$; NII_User $\beta = -1.592$, $p = 0.080 > 0.05$; iCMS_User $\beta = 0.388$, $p = 0.652 >$ This was given the interpretation that the p-values compared with all were higher than 0.05. The null was thus not rejected.

H01: there was no statistically significant effect of SWS on trade facilitation. Table 4.15 indicates that at 0.05 confidence level other factors held constant, SWS positively and significantly affected Trade Facilitation (Model 2) with a $\beta = 0.411$, $p = 0.000$ (2.000). This was interpreted according to the results that the p-value was below 0.05, and the t-value exceeded 2.000. The null hypothesis was hence rejected, and the alternative hypothesis (H1) accepted that SWS significantly affected trade facilitation. In Model 4, however, the effect was non-significant ($\beta = -0.555$, $p = 0.387 > 0.05$), suggesting a possible multicollinearity effect.

4.5 Discussion of the Findings

Correlation analysis revealed a strong, positive significant correlation between the Single Window System (SWS) and Trade Facilitation ($r = 0.801$, $p = 0.000$), indicating that changes in SWS influence trade outcomes. Multiple regression confirmed SWS positively and significantly affected Trade Facilitation in Model 2 ($\beta = 0.411$, $p < 0.05$), implying a unit increase in SWS yields a 0.411-unit rise in facilitation, holding other variables constant. This aligns with Kabui (2018), who, via the Technology Acceptance Model (TAM), noted that effective SWS streamlines customs operations, reduces paperwork, and shortens processing

time, a practice increasingly adopted in East African trade centers. Similarly, TMEA (2020) observed that digital

Non-Intrusive Inspection (NII) showed a strong positive significant correlation with Trade Facilitation ($r = 0.681$, $p = 0.000$), suggesting enhancements in NII could boost facilitation. However, regression analysis indicated no significant effect in Model 2 ($\beta = 0.139$, $p > 0.05$), though it approached significance in Model 4 ($\beta = 0.859$, $p = 0.059$), implying limited direct impact without supporting factors. This underscores NII's potential to minimize physical inspections and delays but highlights infrastructure dependencies. Pino et al. (2022), through Systems Thinking, argued that non-intrusive techniques shorten inspection times, yet success hinges on robust infrastructure, explaining the mixed results in Kenyan contexts where trade points face limitations.

The Integrated Customs Management System (iCMS) exhibited a strong significant correlation with Trade Facilitation ($r = 0.791$, $p = 0.000$), with changes in iCMS affecting trade processes. Regression results demonstrated a significant positive influence in Model 2 ($\beta = 0.427$, $p < 0.05$), where a unit increase in iCMS leads to a 0.427-unit rise in facilitation. The effect diminished in Model 4 due to multicollinearity. These findings echo Angalwa (2022), who, using Diffusion of Innovations (DOI) theory, posited that integrated systems enhance efficiency via data centralization, though semi-automated implementations in Kenyan customs introduce inefficiencies and reduce predictability in duty assessments.

User Competency displayed a strong, positive significant correlation with Trade Facilitation ($r = 0.655$, $p = 0.000$), indicating that skill improvements influence trade outcomes. Regression analysis showed no significant direct effect in Model 3 ($\beta = 0.119$, $p > 0.05$), with non-significant interactions in Model 4, suggesting limited moderating role possibly due to training gaps or multicollinearity. Abrahams et al. (2023), supporting TAM and DOI, emphasized that user training boosts technology adoption, but the insignificance here implies the need for targeted interventions to address competency deficits in Kenya.

5. Conclusion

Digital technologies significantly impact trade facilitation in Kenya. SWS enhances cargo clearance accuracy and timeliness, reducing inefficiencies. NII offers moderate benefits through scanning and risk assessment, but is constrained by infrastructure, prolonging manual checks and costs. iCMS strongly supports integration and efficiency, though automation gaps hinder full potential. User Competency, while correlated, lacks significant moderation, underscoring training needs. Overall, these technologies promote revenue maximization, cost reduction, barrier mitigation, and competitiveness. Customs valuation contributes the least, while goods verification aids post-declaration processes. Future research should explore infrastructure upgrades and competency programs.

6. Recommendations

It is recommended that policymakers use these study findings to prioritize the development (formulation) of comprehensive digital trade facilitation policies that mandate the automation of customs procedures, the use of electronic documentation, and inter-agency system integration. Clear timelines and enforcement mechanisms would ensure accountability and compliance. Also, legislation should be enacted to facilitate (enhance) cooperation among border control agencies (e.g., KRA, KEBS, KEPHIS, KPA) under one national single window

system for real-time coordination and to prevent (eliminate) duplication of efforts, thereby improving trade efficiency. Policymakers should also consider establishing independent oversight bodies to ensure the execution (implementation) of trade facilitation reforms. This would make sure that the digital procedures will be (are) in accordance with international standards and its implementation responds (is responsive) to stakeholders' needs on the ground.

The policy makers are therefore recommended to use the study findings to prioritize the formulation of comprehensive digital trade facilitation policies that mandate the automation of customs procedures, adoption of electronic documentation, and an inter-agency system. There will (would) be accountability and compliance due to clear timelines and implementation (enforcement) mechanisms. A law needs should to be passed to improve (enhance) the cooperation of border control organizations (e.g., KRA, KEBS, KEPHIS, KPA) within the framework of a single national single window system. This would provide real-time coordination, remove (eliminate) duplicated efforts, and improve trade efficiency. Policy makers are expected to establish separate supervisory (oversight) institutions to keep an eye on the trade facilitation reforms. This would not only make sure that digital processes comply (are aligned) with international standards, but also remain (are) sensitive to stakeholder needs on the ground.

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