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Digital Transformation in Nigeria Customs Service: Evaluating the Impact of E-Customs and Single Window Platforms on Trade Facilitation

[1] Akomolehin Francis Olugbenga, [2] Akomolehin Victor Bolawale
[1] Department of Finance, Afe Babalola University, Ado - Ekiti, Ekiti - State, Nigeria
[2] Department of Economics, Ekiti State University, Ado - Ekiti, Nigeria
[2] Examination Unit, Nigeria Custom Service, Tincan Island, Apapa, Lagos, Nigeria

Corresponding Author: **Akomolehin Francis Olugbenga**

Abstract
Digital transformation has become a cornerstone of modern customs administration globally, with countries increasingly adopting electronic platforms to enhance trade efficiency, transparency, and revenue performance. This study examines the impact of Nigeria's e-Customs (Trade Modernisation Project) and the National Single Window (NSW) system on trade facilitation across three strategic trade corridors: Lagos Ports, Seme Border, and Onne Port. Using a qualitative-dominant methodology that integrates policy review with comparative case studies, the research evaluates changes in clearance time, revenue mobilisation, corruption vulnerability, and procedural transparency. Findings reveal that digital reforms have contributed to significant improvements in clearance efficiency and revenue accuracy in Lagos and Onne, while Seme Border recorded moderate gains due to persistent informality and infrastructural constraints Across all sites, reductions in face-to-face interactions and increased auditability enhanced transparency and helped curb corruption opportunities. However, the impacts remain uneven, shaped by differences in institutional capacity, digital literacy, and infrastructure reliability. The study highlights the need for deeper inter-agency integration, stronger risk management systems, targeted capacity building, and sustained stakeholder engagement to maximise the benefits of digital customs reforms. Recommendations are provided to guide policy, operational reinforcement, and further research in Nigeria's evolving digital trade ecosystem.

Keywords: Digital Customs, Single Window, Trade Facilitation, Customs Revenue, Corruption Reduction, Nigeria Customs Service

1. Introduction

1.1 Background and Rationale

The global trade environment has seen significant changes during the last ten years, driven by the widespread adoption of digital customs infrastructure and National Single Window (NSW) technologies, which are designed to facilitate trade through efficient border management. The implementation of the WTO Trade Facilitation Agreement (WTO-TFA) in 2017 has prompted WTO member countries to increasingly rely on digitalization, data harmonization, and border management as an opportunity to enhance trade competitiveness (Amegashie & Sun, 2020; Mustra, 2021) [5, 16]. Research conducted in Asia, Latin America, and the Middle East confirms the significant impact of digital customs infrastructure on reducing paperwork, border clearance times, and transaction costs, as well as improving transparency and certainty in international trade (Chen & Mattoo, 2023; Rahman & Idris, 2022) [8, 20]. The digital customs infrastructure roadmap for the establishment of the African Continental Free Trade Area (AfCFTA) and the cross-border paperless trade program initiated by UNESCAP are further evidence of the global trend toward digital infrastructure as the basis for modern customs administrations (Kassim *et al*., 2021; UNESCAP, 2022) [12, 21]."

On the other hand, Nigeria's trade environment still grapples with various structural impediments. For instance, clearance delays, port congestions, revenue leakages, corruption risks, and disjointed processes have long hindered the efficiency of Nigeria's customs service and the overall competitiveness of Nigerian ports. These have been major impediments for Nigeria's customs service, as highlighted by various studies, including Adewale *et al*. (2020) [1]; Ekeocha & Nwosu, (2021) [10]. Seaports like Apapa and Tin-Can Island experience notable clearance delays due to cumbersome documentation processes, physical

checks, and disjointed processes. These have become major impediments for Nigeria's trade efficiency, given that clearance delays have notable logistical costs for traders.

In response to these systemic inefficiencies, the Nigeria Customs Service has undertaken a holistic digitalization drive through its Trade Modernization Project, or e-Customs Project, which seeks to automate all customs processes, implement advanced risk management tools, integrate scanning tools, and apply data analytics to optimize revenue generation, eliminate discretion, and optimize trade facilitation outcomes (Akinyemi & Odumosu, 2022; Bello, 2024) [3, 7]. The Nigeria Customs Service's digitalization drive resonates with global trends in customs modernization, including the move towards 'paperless trade.' Complementary to this TMP initiative is the development of the Nigeria Single Window Trade Portal, which is intended to integrate trade-related documents and information within a single digital platform accessible to all trade stakeholders. The NSW is intended to streamline trade procedures among customs and other trade agencies, reduce trade clearance times, and limit physical interactions, as well as enhance trade transparency for traders through real-time access to trade regulations and transactions. This initiative is likely to have strong potential benefits for trade in Nigeria, considering similar trade single windows implemented in Rwanda, Singapore, and Ghana have shown promising outcomes in terms of trade clearance efficiency and lower trade compliance costs for traders, as noted by Ahiable and Mensah (2022) [2] and World Bank (2023) [22].

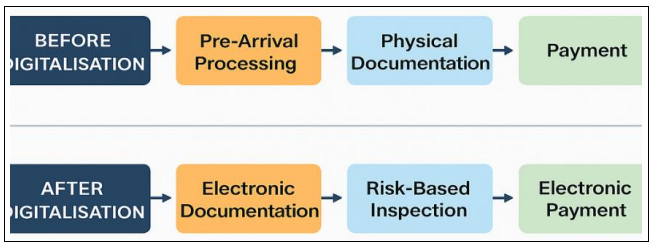

Fig 1: Digital Customs Process Flow—Comparison of Pre- and Post-Digitalisation Procedures

The diagram shows the process of transforming customs clearance from manual, paper-based, and inspection-oriented practices to efficient, technology-enabled practices. The manual processing of cargoes before digitalisation involved physical documentation, inspections, and manual payments, while after digitalisation, electronic documentation, risk-based inspections, and electronic payments are used to reduce clearance time, increase transparency, and minimise human interventions in trade facilitation.

1.2 Research Problem

However, the empirical evidence available on the Nigerian case still seems disjointed. Most available studies have been general in scope and have addressed the topics of either automation and trade facilitation within the ECOWAS region, but have lacked the depth and specificity required to assess the impact of the e-Customs and Single Window initiatives on trade facilitation indicators such as clearance time, revenue mobilization, corruption reduction, and transparency improvement initiatives (Osei-Amponsah, 2020; Danladi & Umar, 2022) [19, 9]. Most available studies have been general in scope and have addressed the topics at the policy level without sufficient analysis at the operational level.

There is, therefore, a critical gap to address, especially with regard to how these frameworks can inform ground-level port and border environments, especially at major trade corridors that include Lagos Ports (Apapa/Tin-Can), Seme Border, and Onne Port, amongst others. These areas have unique operational environments, especially with regard to trade, including maritime trade, informal border trade, and specialized cargo handling, amongst others, and can, therefore, provide an ideal case study to assess how digitalization is felt at ground level, especially with regard to Nigeria's digitalization of customs operations.

1.3 Research Objectives

The overall aim of the study is to evaluate how e-Customs automation and the National Single Window platform have influenced trade facilitation outcomes in Nigeria.

1.3.1 Specific Objectives

To assess the extent to which e-Customs and NSW reforms have reduced clearance time at major ports and borders.

To examine the effect of digital customs reforms on revenue performance in the Nigeria Customs Service.

To analyse how digital platforms influence corruption opportunities and transparency in customs processes.

To compare the impact of these reforms across Lagos Ports, Seme Border, and Onne Port, identifying location-specific variations.

1.4 Research Questions

How have e-Customs and NSW platforms affected cargo clearance time in Nigeria?

What impact have these digital reforms had on customs revenue generation?

How have e-Customs and NSW influenced corruption risks and transparency in customs operations?

How do these impacts differ across Lagos Ports, Seme Border, and Onne Port?

1.5 Scope and Limitations

The present study, therefore, is bounded geographically, temporally, as well as methodologically, in ways that are consonant with its own analytical concerns. In terms of geography, this study focuses on three trade gateway nodes that are strategically critical to Nigeria, namely, Lagos Ports, Seme Border, as well as Onne Port, which together represent Nigeria's major trade corridors, be it maritime or through land borders, to produce a representative picture of customs operations across all modes of trade entries. In terms of time, this study covers all periods from pre-digital times in customs administrations through to the implementation, as well as full maturity, of the e-Customs, as well as the National Single Window, projects, roughly spanning 2014 to 2025. Despite this clear bounding, this study, however, acknowledges that it faced some challenges, particularly with regards to insufficient data from the Nigeria Customs Service, as well as difficulties in obtaining perceptions from relevant stakeholders, which were partly caused by institutional sensitivities, although methodological triangulations were used to mitigate these issues through reliance on relevant policy documents, as well as case evidence, to add robustness to this study.

2. Conceptual and Theoretical Framework

2.1 Conceptual Review

Fig 2: Stakeholder Interaction Map Under the National Single Window (NSW) Platform

The Stakeholder Interaction Map shows the central role of the National Single Window in integrating customs, port authorities, quarantine, immigration, SON, NESREA, shipping lines, freight forwarders, and traders within a unified digital ecosystem. By consolidating regulatory submissions and enabling real-time data exchange, the NSW reduces duplication, enhances coordination, accelerates clearance processes, and strengthens transparency across Nigeria's trade facilitation environment.

2.2 Conceptual Review

2.2.1 Digital Customs (e-Customs)

Digital customs, commonly referred to as e-Customs, denote the transformation of conventional, paper-based customs procedures into automated, ICT-enabled systems that support electronic documentation, risk management, cargo tracking, and coordinated border processing. Contemporary customs scholarship identifies digitalisation as a core pillar of modern border management, enabling greater procedural efficiency, predictability, and accountability (Hameri & Laari, 2020) [11]. By embedding rules and workflows into electronic systems, e-Customs reduces reliance on manual processing and discretionary decision-making, thereby strengthening the integrity of customs operations (Ayele, 2021; Rahman & Idris, 2022) [6, 20].

Modern e-Customs platforms integrate key functionalities such as automated valuation, risk profiling, non-intrusive inspection technologies, and data analytics. These tools enhance enforcement capacity while simultaneously facilitating legitimate trade through expedited clearance channels (Kavuma & Mugume, 2023) [13]. In developing economies, empirical evidence links e-Customs adoption to improved revenue mobilisation and streamlined cargo throughput, reflecting reduced manual errors and fewer opportunities for leakages (Akinyemi & Odumosu, 2022) [3]. Digital customs therefore functions not only as an efficiency-enhancing mechanism but also as a governance instrument that reshapes institutional behaviour.

2.2.2 Single Window Systems

Single Window (SW) systems are integrated electronic platforms that allow traders to submit all regulatory documents required for import, export, and transit transactions through a single entry point. By coordinating information flows among customs, port authorities, quarantine agencies, standards organisations, and other border institutions, Single Windows address long-standing inefficiencies arising from fragmented regulatory mandates. Empirical studies demonstrate that SW systems reduce administrative burdens by harmonising procedures, eliminating redundant documentation, and enabling parallel rather than sequential processing of approvals (Ahiable & Mensah, 2022; Chen & Mattoo, 2023) [2, 8].

Evidence from multiple regions indicates that effective Single Window implementation contributes to shorter clearance times, lower transaction costs, and greater procedural predictability (Mohammed & Ibrahim, 2021) [15]. Importantly, when integrated with e-Customs platforms, Single Windows create a unified digital ecosystem that enhances risk management, regulatory compliance, and inter-agency coordination (Mustra, 2021; World Bank, 2023) [16, 22]. The effectiveness of these systems, however, depends on the depth of integration, system reliability, and institutional commitment to coordinated border management.

2.2.3 Trade Facilitation: Time, Cost, and Predictability

Trade facilitation refers to the simplification, harmonisation, and modernisation of trade procedures with the objective of improving the efficiency of cross-border commerce. Central dimensions of trade facilitation include clearance time, transaction costs, and predictability of border processes (Liu & Yue, 2021) [14]. Empirical research consistently shows that time delays at borders impose costs equivalent to tariffs, particularly for developing countries facing logistics and infrastructure constraints (Zhao & Sun, 2022) [24].

Clearance time remains a critical performance indicator, as faster cargo release improves supply chain reliability, reduces inventory holding costs, and enhances firms' competitiveness (Amegashie & Sun, 2020) [5]. Cost reductions—stemming from lower demurrage charges, fewer inspections, and streamlined documentation—further improve operational efficiency (Rahman & Idris, 2022) [20]. Predictability is equally important; opaque procedures and inconsistent enforcement increase uncertainty, discourage investment, and raise the cost of doing business (Okonjo & Ogundele, 2023) [18]. Digital customs and Single Window platforms directly address these dimensions by standardising processes, automating approvals, and providing real-time information to traders.

2.2.4 Corruption and Transparency in Customs

Corruption constitutes a persistent challenge in customs administration, particularly in contexts characterised by manual procedures, weak oversight, and fragmented institutional arrangements. Empirical studies associate customs-related corruption with revenue losses, clearance delays, and distortions in trade flows, driven largely by discretionary practices during valuation, inspection, and document verification (Danladi & Umar, 2022; Ekeocha & Nwosu, 2021) [9, 10]. High levels of human interaction create opportunities for informal payments and procedural manipulation.

Digitalisation through e-Customs and Single Window systems offers a strategic response to these vulnerabilities by automating decision rules, reducing face-to-face interactions, and generating electronic audit trails that enhance accountability (Ayele, 2021; Bello, 2024) [6, 7].

Evidence from several African countries demonstrates that digital border reforms strengthen transparency by improving traceability, standardising procedures, and weakening networks of informal exchange (Ahiable & Mensah, 2022; Kavuma & Mugume, 2023) [2, 13]. Transparency, in this sense, reflects the visibility and clarity of customs procedures, as well as traders' access to accurate, real-time information on regulatory requirements and cargo status (Rahman & Idris, 2022) [20].

In the Nigerian context, these conceptual relationships are shaped by port congestion, informal border trade, fragmented agency mandates, and uneven institutional capacity, making location-specific analysis essential. The interaction between digital customs reforms, operational mechanisms, and trade facilitation outcomes therefore varies across maritime ports and land borders, underscoring the need for contextualised empirical assessment. These conceptual linkages are synthesised in the study's conceptual framework (Figure X), which illustrates how e-Customs and Single Window reforms influence clearance efficiency, revenue performance, corruption exposure, and transparency through mediating operational mechanisms and moderating institutional conditions.

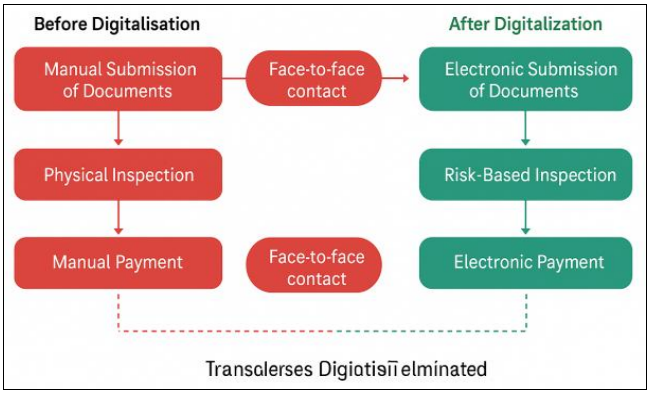

Fig 3: Corruption Vulnerability Reduction Model under Digital Customs Reforms

The model demonstrates how digital customs reforms replace manual, high-contact processes with automated, technology-driven workflows. By shifting from physical document submission, manual inspections, and cash payments to electronic documentation, risk-based inspections, and digital payments, the number of human interaction points decreases. This reduction weakens channels for unofficial payments, strengthens audit trails, and enhances transparency and accountability across the clearance process.

For example, in the Nigerian context, these conceptual relationships are mediated by considerations of port congestion, informal trade at borders, fragmented agency mandates, and uneven institutional capacity, underscoring the need to analyze these relationships from a localized perspective. The relationships between digital customs, operational processes, and trade facilitation outcomes are unique to each maritime port and/or borders, underscoring the need to evaluate these relationships from an empirical standpoint. The conceptual relationships outlined above are synthesized in a conceptual framework (Figure X) that specifies the relationships between e-Customs, Single Window, clearance efficiency, revenue performance, corruption risk, and transparency, mediated through operational processes and moderated by institutional conditions.

2.3 Theoretical Review

The theoretical foundations of digitalization in customs administration are mainly based on Trade Facilitation Theory in relation to New Trade Theory, as well as Institutional and Governance Theory. The aforementioned theories provide a theoretical lens to analyze various impacts of digitalization in customs administration. According to Trade Facilitation Theory, reduction of non-tariff barriers such as delays, administrative complexities, and regulatory complexities in international trade would have significant impacts on trade volumes, trade competitiveness, and welfare, particularly in developing countries (Amegashie & Sun, 2020; Liu & Yue, 2021) [5, 14]. Based on such theoretical foundations, New Trade Theory indicates that improvements in supply chain efficiency and reduction of transactional complexities would provide better economies of scale, better import/export complexities, and better participation in global supply chains (Zhao & Sun, 2022) [24]. According to various empirical findings presented in MDPI journals, investments in digitalization of customs administration, single windows, and coordinated management would have significant impacts on reducing logistics complexities, improving predictability, and enhancing efficiency in customs clearance, particularly in relation to improving trade performance (Rahman & Idris, 2022; Chen & Mattoo, 2023) [20, 8]. The e-Customs initiative and single window reform in Nigeria are in line with such theoretical foundations in relation to improving non-tariff operational complexities in Nigeria.

While providing an alternative perspective for understanding the customs clearance process, Institutional and Governance Theory seeks to explain the behavior of customs officials, traders, and other actors within the customs ecosystem through their interaction with rules and ICT systems. According to Institutional and Governance Theory, institutions are key drivers of transparency, inefficiency, or corruption within public agencies (North, 1990; Danladi & Umar, 2022) [17, 9]. In customs clearance systems that are manual-intensive, involving numerous documents and discretionary decision-making, institutions are likely to exhibit rent-seeking behavior, procedural opacity, and uneven regulatory enforcement (Ekeocha & Nwosu, 2021) [10]. In contrast, digital customs clearance systems that introduce e-Customs and Single Window systems change these institutions by limiting discretionary decision-making and instituting digital trails for customs clearance (Ayele, 2021; Kavuma & Mugume, 2023) [6, 13]. Studies that focus on the role of governance within customs clearance systems, conducted by the World Bank, similarly find that digital customs clearance systems enhance the performance of customs institutions through increased transparency in customs data, lower risks of corruption, and improved monitoring of compliance (World Bank, 2023; Bello, 2024) [22, 7]. Thus, Institutional and Governance Theory is an effective framework for explaining the role of digital customs clearance systems in Nigeria on customs clearance time, revenue, transparency, and corruption.

2.4 Empirical Literature Review

Existing bodies of knowledge on digital customs and trade facilitation show that, across all regions, implementation of

e-Customs and SWs leads to improvements in trade facilitation, trade costs, as well as trade volumes. Studies undertaken in regions such as Asia, Latin America, as well as the Middle East show that implementation of SWs leads to substantial reductions in documentary requirements as well as processing times, which improves reliability as well as overall competitiveness of trade supplies (Chen & Mattoo, 2023; Rahman & Idris, 2022) [8, 20]. An evaluation undertaken by the World Bank also reveals that implementation of SWs improves release of cargoes through parallel processing as well as reduction of interactions with customs officials, which improves trade facilitation through SWs (World Bank, 2023) [22]. Studies undertaken by UNESCAP show that implementation of cross-border paperless trade leads to reductions in overall trade transaction costs of as much as 25 percent, which demonstrates that digital customs have substantial trade facilitation impacts that can transform trade in developing countries (Mustra, 2021; UNESCAP, 2022) [16, 21]. These global studies are supplemented by trade journals, including Oxford University Press publications, which show that digitalization improves transparency, as well as trade facilitation, through reduction of non-tariff barriers, which improves trade growth significantly (Amegashie & Sun, 2020) [5].

With regard to African countries, existing studies have identified similar benefits. A study on East African Community (EAC), for instance, has noted how customs reforms have helped reduce border crossings through automated customs systems, particularly in Kenya. The study noted how customs procedures have become efficient due to integrated risk management and minimal human intervention (Kavuma & Mugume, 2023; Ahiable & Mensah, 2022) [13, 2]. The Kenya Revenue Authority, for instance, has noted how its ICT reforms have helped improve regulatory coherence and enhance efficiency in customs procedures. Trademark Africa and other African development organizations have noted how countries have benefited through Single Window and automated customs systems, which have helped reduce logistics costs and enhance procedural efficiency. In ECOWAS countries, studies have noted how customs integrity has been strengthened through coordinated border management, which has helped promote integration (Osei-Amponsah, 2020; Danladi & Umar, 2022) [19, 9]. African studies have noted how customs reforms have helped reduce rent-seeking and increase efficiency, which has helped promote customs operations. In particular, studies have noted how customs operations have become predictable, which has helped promote customs operations and boost trader confidence (Ekeocha & Nwosu, 2021) [10].

Moreover, literature on trade facilitation in relation to West Africa and ECOWAS indicates that there is a significant correlation between trade facilitation, shorter border times, and economic welfare. The MDPI literature focuses on trade facilitation in relation to ECOWAS, particularly in relation to reducing administrative burdens and facilitating inspections, as it can have a significant impact on improving trade volumes, lowering prices, and improving income levels of households that are engaged in cross-border trade (Zhao & Sun, 2022; Liu & Yue, 2021) [24, 14]. The literature also indicates that these issues are particularly problematic for small traders, particularly in relation to agriculture, highlighting that digitalization can have significant effects at a national level. Nigeria's digital customs literature reveals that, although there is significant development, there are areas that need improvement. For example, previous digitalization projects, including ASYCUDA and the Nigeria Integrated Customs Information System (NICIS), have shown positive developments, although they have been limited by lack of integration, infrastructural challenges, and the need to involve manual processes (Adewale, 2020; Okonjo & Ogundele, 2023 [18]). According to various publications on ScienceDirect, these digitalization projects, although showing positive developments, have shown limited effectiveness, especially when dealing with the issue of reducing corruption, due to the need for manual intervention between traders and customs officials (Ekeocha & Nwosu, 2021) [10]. For example, various publications on Nigeria's Trade Portal, although showing positive developments, have shown that this digitalization project is limited due to inconsistencies at land borders (Mohammed & Ibrahim, 2021) [15]. Additionally, although anti-corruption measures have shown positive developments, especially when dealing with the issue of auditability, these reforms have shown to be limited due to inefficient processes (Bello, 2024; Akinyemi & Odumosu, 2022) [7, 3]. Despite this, there are still glaring gaps, with few studies employing the policy analysis approach and the multi-site case study design, focusing mainly on the critical areas such as Lagos Ports, Seme Border, and Onne Port, which are the main areas of operation. Notably, the literature has mainly focused only on one area and the national dimension without exploring the performance across different areas of operation (Osei-Amponsah, 2020) [19]. Furthermore, whereas the literature across the world and in the African region has shown the reduction in time and cost attributed to digitalization, few studies have concurrently measured clearance time, revenue, risks, and transparency in the Nigerian context (Danladi & Umar, 2022) [9]. More importantly, the literature has not sufficiently assessed the impact and performance of the new Trade Modernisation Project, also known as e-Customs, and the new National Single Window, which were introduced with the aim of revolutionizing the system since 2019 (Bello, 2024) [7]. This study, therefore, fills the information vacuum with the aim of providing comprehensive, multi-dimensional, and specific analysis of the digital revolution in the Nigerian customs administration system.

2.5 Conceptual Framework

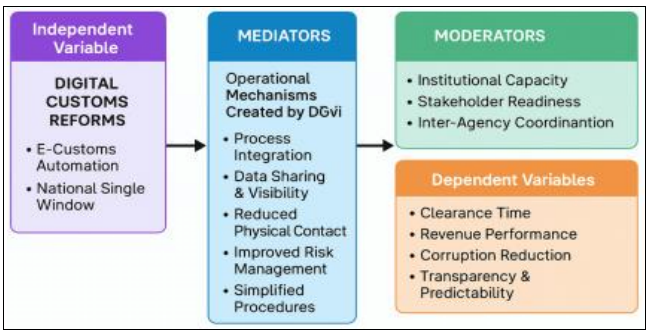

Fig 4: Conceptual Framework Linking Digital Customs Reforms to Trade Facilitation Outcomes

The conceptual framework shows how digital customs reforms—driven by e-Customs automation and the National Single Window—enhance trade facilitation outcomes.

Through mediating mechanisms such as process integration, risk management, data sharing, and reduced physical contact, these reforms reduce clearance time, improve revenue, curb corruption, and strengthen transparency. Institutional capacity, stakeholder readiness, and inter-agency coordination moderate the strength of these effects.

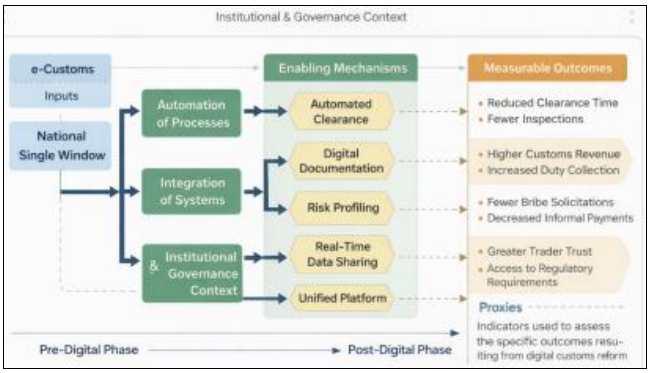

Fig 5: Conceptual Framework of Digital Customs Reforms and Trade Facilitation Outcomes in Nigeria

This framework illustrates how e-Customs automation and the National Single Window (independent variables) influence trade facilitation outcomes through key operational mechanisms, within an enabling institutional and governance context, highlighting measurable proxies for clearance efficiency, revenue performance, corruption reduction, and transparency.

Explanatory Note on the Conceptual Framework

The conceptual framework identifies the pathway for the impact that digital transformation initiatives in the customs administration in Nigeria have on trade facilitation. A key component within the conceptual framework is the Independent Variable (IV) – Digital Customs Reforms. These include the e-Customs automation and the National Single Window (NSW). These reforms have been described as having the potential for groundbreaking innovations in the trade facilitation arena.

This can be done through the use of a range of Mediating Mechanisms, which facilitate an understanding of the ways in which digitalization leads to changes. This includes better integration of processes, better management of risks, better sharing of real-time data, and minimizing direct engagement between customs officers and traders.

The framework also takes into consideration that "the extent to which digital reform outcomes are consistent and significant across cases depends on several Moderating Variables. The latter refer to institutional capacity (infrastructure in information and communication technology, as well as digital skills of officers), to stakeholder readiness (compliance of traders, as well as their digital literacy skills), and to inter-agency coordination (harmonization of customs, ports, and regulatory authorities' practices)."

Finally, the reforms affect the Dependent Variables (DVs)—trade facilitation outcomes, which comprise the following four measures: reduced clearance times, better revenue performance, reduced opportunities for corruption, and increased transparency and predictability. The reform outcomes conform to global standards set under the WTO TFA and global best practice in border management.

In conclusion, it is clear that the framework highlights that digital customs reforms have the most significant impact when there is complementing progress in technology, along with strong institutions, capacities, and governance systems. This, therefore, promotes a holistic approach to digitalization in Nigeria's trade environment.

3. Research Methodology

3.1 Research Design

The methodological design for this study is qualitative dominant with an emphasis on an extensive review of policies accompanied by a comparative case analysis design. This methodological design is appropriate for the study because the structural, procedural, and institutional aspects of digital customs reforms in Nigeria can effectively be explored. This methodological design is appropriate because, according to established methodological standards, the study can benefit from a comparative case analysis design to ensure an interpretation of the variations in the effectiveness of reforms in different settings, while the review of policies situates the study within the global, regional, and national context for reforms (Theseus, 2019). This methodological design is appropriate because the study is focused on a systemic rather than an attribute-based analysis, which is the case for e-Customs and the Single Window systems.

3.2 Data Sources

The research employs multiple data sources for methodological triangulation. The first category of data includes policy and institutional documents such as the World Trade Organization Trade Facilitation Agreement (TFA), Circulars and operational guidelines of the Nigeria Customs Service, documentation of the Trade Modernisation (e-Customs) Project, National Single Window Policy Documents, trade facilitation assessments carried out by multilateral institutions such as the World Bank and African Development Bank. The data sources shed light on the legal, operational, and institutional context of Nigeria's digital reform journey and allow for comparisons with global best practices.

The second category of data includes case study evidence, such as reports on port efficiencies, cargo throughputs, time releases (where available), as well as Nigeria Customs Service newsletters and bulletins. Moreover, qualitative information, as gathered through interviews or focus groups conducted with customs officers, freight forwarders, terminal operators, shipping agents, as well as cross-border traders, can be included as additional information. This will allow an understanding of the reforms from the perspective of those affected, thereby providing additional depth to the analysis. Data from other official trade portals and trade information system databases can also be used as additional evidence.

3.3 Case Selection and Description

Three strategic trade locations were purposively selected to represent Nigeria's varied customs operating conditions:

The two ports, Apapa and Tin Can Island, are the main ports of the country and are the main gateway for cargo traffic. These ports are the critical testbed for the assessment of the effects of digitalization on cargo traffic and the complex processes of documentation.

Seme Border, located on the Nigeria-Benin trade corridor, is an epitome of the intricate nature of land border trade, where informal trade, human clearance, and agency interactions are integral to the border trade process. Seme Border provides an contrasting environment where digitalisation needs to address the long-standing socio-economic dynamics of border trade.

Onne Port is a specialized maritime infrastructure catering to the needs of containerized cargo, oil and gas equipment, and industrial cargo operations. Its operational focus creates a specialized environment for examining the interface between digital systems and specialized cargo operations.

The tri-site approach provides greater analytical depth because the sites allow for a form of comparative analysis within the context of large-volume maritime, land border, and specialised port settings.

Fig 6: Digital Customs Value Chain Diagram

The Digital Customs Value Chain illustrates the end-to-end transformation of cargo clearance under modernised customs systems. Beginning with pre-arrival processing, the workflow incorporates electronic documentation, automated risk profiling, targeted inspection, electronic release, and post-clearance audit. Each stage reflects the shift from manual, fragmented procedures to integrated, technology-enabled processes that enhance efficiency, accuracy, transparency, and compliance across the customs environment.

3.4 Variables, Indicators, and Measurement

The analysis is structured around two core categories of variables: Digital customs implementation and trade facilitation outcomes.

Digital Customs Implementation Variables

These capture the scope and quality of e-Customs and Single Window deployment and include:

System functionality (availability of electronic documentation, automated valuation, risk management modules).

Coverage and user uptake (extent of agency integration, proportion of transactions processed electronically).

Inter-agency connectivity (data sharing between customs, port authorities, regulatory agencies, and security bodies).

Trade Facilitation Outcome Indicators

These indicators measure the effectiveness of reforms:

Clearance time: measured as the average time from cargo arrival to release, enabling before–after comparisons consistent with trade facilitation metrics used globally.

Revenue performance: assessed through trends in customs revenue, incidence of leakages, and improvements in valuation accuracy following digitalisation.

Corruption and transparency: operationalised through the frequency of face-to-face interactions required for clearance, incidence of unofficial payments, procedural predictability, and the presence of audit trails within digital systems.

These indicators reflect the multidimensional nature of trade facilitation and align with international evaluation frameworks.

3.5 Methods of Data Collection

Three principal methods underpin data collection:

Document Analysis: reviewing policy instruments, legislative frameworks, project reports, and operational guidelines to establish the structural basis of Nigeria's digital reforms.

Key Informant Interviews and Stakeholder Surveys (where feasible): obtaining experiential insights from customs officials, freight forwarders, terminal operators, and traders to assess reform implementation and identify operational challenges.

Secondary Quantitative Data: analysis of revenue records, clearance time series, cargo throughput data, and port performance metrics, facilitating empirical comparison of pre- and post-digitalisation outcomes.

Together, these methods provide a robust evidential foundation for triangulating findings.

3.6 Methods of Data Analysis

The study employs both qualitative and quantitative analytical techniques:

Qualitative Content Analysis is used to evaluate policy documents, institutional reports, and interview transcripts. This method supports thematic interpretation of reform design, implementation challenges, and stakeholder experiences.

Descriptive Statistics are applied to quantitative indicators such as clearance time, revenue performance, and cargo throughput, enabling temporal comparisons that highlight changes attributable to digital reforms.

Cross-Case Comparative Analysis synthesises findings from Lagos Ports, Seme Border, and Onne Port to identify similarities, divergences, and contextual factors influencing reform performance across sites.

This mixed analytical approach enhances validity and ensures comprehensive interpretation of results.

3.7 Analytical Rigor and Reliability Considerations

With respect to the analysis's internal validity, it must be stated that this study's methodical approach to the analysis of the subject matter incorporates a methodical triangulation approach. In other words, the analysis incorporates the use of policy and institutional documents, comparative case study findings, and outcome-based indicators with respect to the time taken for the clearance of cargo, revenue performance, corruption risk, and transparency. In this respect, the analysis incorporates the concept of cross-validation with respect to the findings of the analysis of the Lagos ports, Seme border, and Onne ports.

Furthermore, the analytical framework follows a before-after research logic, comparing customs conditions before going digital and customs outcomes following the introduction and implementation of e-Customs and the National Single Window. The before-after research design helps identify customs outcomes attributable to e-Customs and the National Single Window, controlling for structural differences across trade corridors. Most importantly, however, this study does not rely on confidential microdata for customs operations. Instead, it aggregates publicly accessible policy and operation reports, time releases, and

stakeholders' accounts, which ensures transparency and replicability in research.

Reliability also gets a boost as the material gets cross-verified through a variety of sources, including official publications, independent views, and the narratives put forward by the stakeholders. Greater credence is given to the views that have been supported by a majority of the sources as opposed to the views that have been put forward by a particular source.

3.8 Ethical Considerations

The research design adheres to the ethics that have been established for policy research and field research. Informed consent and voluntary participation are the bases on which the research subjects or the interviewees participate. Confidentiality and stringent data protection laws are followed with regard to sensitive information that pertains to the operational information of the Nigeria Customs Service.

4. Case Study Presentation and Analysis

4.1 Lagos Ports Case

Lagos Ports, which include Apapa and Tin Can Island Ports, remain Nigeria's most prominent and complex ports. These ports account for most containerized, bulk, and general cargo shipments. The ports function in an intricate institutional environment that includes customs, ports, shipping companies, terminal operators, and various government agencies. The ports have traditionally experienced an overwhelming volume of business that often results in delayed handling of shipments. This situation often culminates in increased logistics costs and lower port efficiency. Therefore, the ports have traditionally faced issues that negatively impact efficiency, thus making them less competitive. (Okonjo & Ogundele, 2023) [18].

Lagos Ports was one of the earliest beneficiaries of the digitalisation drive for customs operations. This began with the expansion of the digital systems introduced during the implementation of the NICIS II, which further expanded the electronic declaration, valuation, and payment systems. This was followed by the implementation of the Trade Modernisation Project, which further entrenched the digitalisation drive for customs operations from 2019 to 2024. This included risk profiling, scanning integration, and end-to-end digitalisation for the operations. In addition, the integration with the national single window facilitated the submission and processing of documents in a consolidated manner for the customs and related agencies.

However, empirical data suggests that there was an indicative reduction in average clearance times, along with an improvement in the predictability of workflows and inspections, with digital system adoption (Akinyemi & Odumosu, 2022) [3]. Additionally, improvements have been seen in terms of revenue, owing to an improvement in valuation accuracy, automated reconciliation, and the curtailment of leakage due to diminished discretionary intervention (Ekeocha & Nwosu, 2021) [10]. Transparency improvements have been indicated through an expansion of electronic audit trails, along with a reduction of face-to-face interactions, curtailment of informal payment opportunities, and an improvement in trader confidence (Ayele, 2021) [6].

Despite the above successes, there are operational issues that need to be worked on. For instance, scanner outages or periods of interrupted scanning activity and port congestion have remained a challenge that affects the optimal efficiency that can be realized with the digital reform.

4.2 Seme Border Case

Seme Border, along the Nigeria-Benin trade route, is an extremely busy land border point that serves as an intermediary for both formal and informal trade. The environment of this border is marked by limited agency presence, multiple check points, and socio-economic factors dominated by small-scale trade. This has led to significant delays, high transaction costs, and illegal costs (Danladi & Umar, 2022) [9].

The utilisation of e-Customs modules and NSW documentation systems at Seme has been able to introduce electronic systems into the environment, which has traditionally relied on manual systems. There has been simplification and minimisation of documentation procedures and the electronic verification of trade documents. However, the utilisation rates have been mixed, owing to the coexistence of electronic systems and traditional forms of trading.

Indeed, available data show that reductions in border processing times, as well as improvements in procedural consistency, are evident where digital systems are successfully used, as shown in Osei-Amponsah (2020) [19]. In addition, digital audit trails, as well as electronic approval, have reduced opportunities for corrupt payments, as evidenced by the replacement of handwritten endorsements with electronic verification, as discussed in Kavuma & Mugume (2023) [13]. However, these improvements are not as pronounced as those seen in maritime environments. Seme Border acts as a stress test for informal conditions surrounding digital customs reforms. The low level of digital literacy among small-scale trader groups, inconsistent power and network connectivity, and limited integration with Benin's border management systems present challenges for customs reforms. These issues underscore the significance of additional support measures for customs reforms for trade facilitation.

4.3 Onne Port Case

Onne Port has a unique place within the Nigerian maritime landscape, serving as a dedicated logistics platform for the handling of containerized cargo, oil and gas equipment, and industrial consignments. The port enjoys the advantage of relatively advanced terminal facilities, a high degree of private sector participation, and cargo types which require a high degree of regulatory accuracy (Ajayi & Ezenwa, 2022) [4].

Onne Port has functioned as a testing site for new, advanced features of the e-Customs system. For example, digitalized applications used at this port include automated manifest submissions, electronic tracking of cargos, as well as inspection planning. An organized environment, as seen in this case, helps to integrate NSW system functionalities with ease, including coordinated document processing with customs, terminal operators, as well as shipping companies (Mohammed & Ibrahim, 2021) [15].

There have been marked improvements in the efficiency of customs clearance, with indications of a decrease in the average time for customs clearance, as well as a decrease in cargo dwell. There have been improvements in revenue collection, which indicate enhanced transparency in revenue valuation, with fewer opportunities for overrides. In comparison to other trade corridors, Onne shows stability in

the outcomes of reforms, which is likely due to high levels of digital literacy. Despite these benefits, however, sustaining these gains in digital performance will demand continuing system upgrades and capacity development. The periodic scanner maintenance problems underscore that reforming customs operations digitally is an evolutionary process.

4.4 Cross-Case Synthesis

The comparative analysis of Lagos Ports, Seme Border, and Onne Port shows that there are converging trends and diverging trends depending on the context with regards to the outcomes of digital customs reforms in Nigeria. In all these ports, it was clear that there was a positive trend with regards to trade facilitation outcomes, especially with regards to e-Customs automation and the introduction of the National Single Window. There were diverging trends, however, with regards to the extent to which these reforms were effective.

One of the significant findings across all of these is that clearance time reductions are particularly significant in environments where operational structure and system use are high. In other words, while Lagos Ports and Onne Ports show significant improvement in clearance time, this is primarily because of automation in documentation, inspection risks, and coordination. At Seme Border, while clearance time is reduced where digital solutions are implemented, it is less consistent. This is an interesting point because it speaks to how complementary factors play an important role in how digital solutions contribute to clearance time.

Improvements in performance with regard to revenue performance, similarly, show differentiated trends. For example, Lagos Port as well as Onne Port show clear improvements in revenue mobilization, which can be ascribed to improved valuation precision, automated reconciliation, as well as reduced discretionary intervention. In contrast, improvements in this regard are not as clear at Seme Border, where informal practices as well as partial system adoption still impact revenue integrity. In this regard, digital customs reforms seem to be most effective with regard to enhancing revenue performance, where enforcement capacity as well as formalized trade practices are strong.

With respect to the governance dimension, all the aforementioned cases demonstrate the reduction in the scope of corruption risk as a result of reduced human interfaces, increased electronic audit trails, and greater procedural transparency. Nevertheless, the extent to which these gains have been achieved differs. The Lagos and Onne ports have better gains in transparency as a result of deeper penetration and institutional control, while the Seme border example shows the limitation to the effectiveness of digitalisation in the face of informality and asymmetrical relationships. As a whole, these findings through cross-case synthesis serve to highlight and illustrate how reforms in digital customs serve as enabling, but not autonomous, measures. Although e-Customs and its complementary component, the National Single Window, provide a basic framework for trade facilitation, these measures' effectiveness is subject to contextual moderators, which include, but are not limited to, reliability, capacities, coordination, and level of trade formality. Overall, these findings serve to support and inform a more nuanced view, wherein, indeed, digitalisation has a positive effect on customs across a range of contexts, but its full transformative effect is best realised.

Table 1: Comparative Trends Before and After Digital Reforms

Indicator	Lagos Ports	Seme Border	Onne Port
Clearance Time	Significant reduction; improved predictability	Moderate reduction; persistent informality slows improvements	Strong reduction; most consistent gains
Revenue Performance	Noticeable increase; improved valuation accuracy	Modest improvement; revenue leakages persist in informal segments	Strong improvement due to structured operations
Corruption / Informal Payments	Decline in manual interactions and unofficial charges	Reduction evident but limited by socio-economic realities	Significant decline; strong audit trail usage
Transparency	High gains via digital documentation and tracking	Medium gains; variable system uptake	High gains; efficient compliance environment

From all three locations, some of the general facilitating factors that were evident included the implementation of automated valuation tools, electronic documentation, as well as improved audit trails that eliminate discretion on the part of humans (Ayele, 2021; Rahman & Idris, 2022) [6, 20]. Enhanced coordination among agencies through NSW also appears as a facilitating factor for improved transparency as well as reduction in processing times.

Nonetheless, there are major bottlenecks, especially regarding infrastructure limitations, digital literacy deficits, and the lack of uniform digital tool implementation for the agencies (Ekeocha & Nwosu, 2021) [10]. For instance, informal trade patterns are a major hindrance at the Seme port, while congestion during access to the port and the scale of operations are major limitations for the Lagos port. In contrast, the relatively better performance at the Onne port underscores the significance of a structured operational environment and the availability of appropriate technology infrastructure.

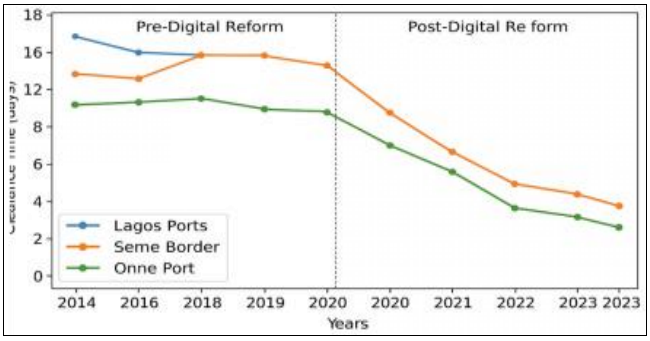

Fig 7: Clearance Time Reduction Trend Before and After Digital Customs Reforms

The trend chart demonstrates a clear decline in clearance times across all three locations following the deployment of e-Customs and National Single Window reforms. Lagos Ports and Onne Port show the steepest improvements due to stronger infrastructure and system uptake, while Seme Border records gradual progress. The visual evidence highlights how automation, risk management, and reduced physical interactions significantly accelerate cargo release processes.

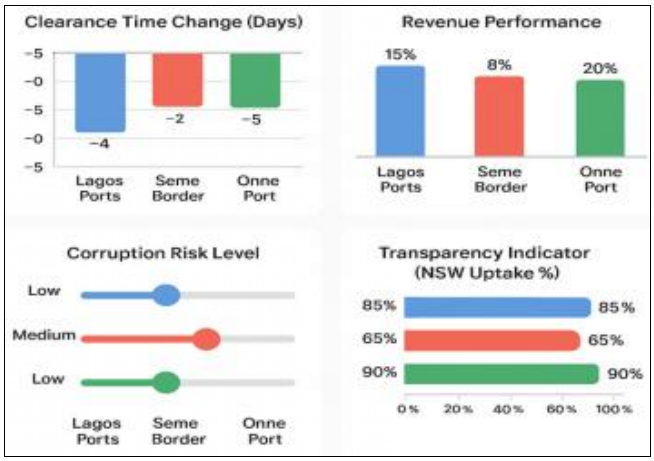

Fig 8: Port-Level Cross-Case Comparison Dashboard for Lagos Ports, Seme Border, and Onne Port

The comparison dashboard highlights how digital customs reforms have produced varied impacts across the three study locations. Lagos Ports show strong improvements in clearance time and transparency, while Onne Port records the highest gains in revenue performance and system uptake. Seme Border demonstrates moderate progress but remains constrained by informality. The visual synthesis enables quick identification of reform strengths, weaknesses, and contextual differences.

Collectively, these case studies illustrate that the impact of Nigeria's digital customs reforms is positive but uneven, shaped by contextual realities at each trade corridor. The findings reinforce the need for tailored implementation strategies, continuous capacity building, and sustained institutional coordination to maximise the benefits of e-Customs and the Single Window system across Nigeria's trade ecosystem.

5. Discussion

The study's results lend strong empirical backing to both the Trade Facilitation Theory and the Institutional Governance Theory, providing a complementary explanation for the role and effectiveness of digital customs reforms. The former highlights the significance of removing NTBs, which include procedure costs, delays, and documentation demands, to improve efficiency, predictability, and welfare gains for all parties involved (Liu & Yue, 2021; Zhao & Sun, 2022) [14, 24]. In the context of the Nigerian study, the introduction of automation and integration reduces the time taken for cargo to clear and makes the release of cargo more certain, especially within a structured port environment. Most importantly, the study suggests digitalisation benefits trade facilitation not just in terms of speed but also in terms of uncertainty and discretionary power, which are major cost factors for developing countries.

Moreover, the Institutional Governance Theory further explains the processes that lead to the above outcomes. By integrating rules into the ICT systems, the digital customs reforms change the incentives facing customs officials and traders. In this way, the digital customs reforms limit the discretion of customs officials and enhance their accountability (Danladi & Umar, 2022) [9]. The decline in the number of informal payment opportunities and the extension of the electronic audit trails to the case locations serve to further affirm that the digitalisation processes can be regarded as an institutional reform measure and not merely a technical one (Ayele, 2021; Kavuma & Mugume, 2023) [6, 13]. However, the results suggest that the success of the reform processes depends on the specific context.

When considered in the context of global literature, Nigeria's case appears to resonate with experiences from East Africa, Latin America, and parts of Asia, which have seen improvements in efficiency, compliance, and transparency with digital customs systems and the introduction of Single Window, as highlighted in recent literature from these contexts (Ahiable & Mensah, 2022; Chen & Mattoo, 2023; Rahman & Idris, 2022) [2, 8, 20]. Like experiences in Kenya and Rwanda, Nigeria's experiences with digital customs systems in its major seaports have seen more significant improvements in efficiency, particularly in contexts with relatively more developed logistics infrastructures. At the same time, Nigeria's experiences diverge from global narratives that have been more positive, particularly with regards to digital customs reforms. Instead, they resonate with recent literature that emphasizes that digital trade systems are extremely context-dependent, particularly with regards to institutional capacities, inter-agency cooperation, and socio-economic contexts.

A critical aspect of this research has been its ability to highlight how Nigeria's reform path has been shaped by political economy factors, as much as technological factors. The tendency for stakeholders to resist reform, and for informal incentive systems built around border trade to continue affecting reform progress, have all contributed to reform progress being less than optimal, particularly in land border environments. In part, these factors explain why technology has tended to have quicker and more predictable effects in ports than in border environments. Nigeria's reform path, therefore, adds an important corrective to global reform literature by highlighting how technology-driven customs reforms, whilst necessary, are by no means sufficient conditions for reform progress.

The results also have relevant policy and operational implications, which are as follows: first, the results emphasize that functional integration between e-Customs and NSW should be further explored to promote data sharing in real time across Customs, Port Authorities, Regulatory Bodies, and Security Agencies. Second, strengthening risk management practices should be prioritized to mitigate issues of over-inspections, which still negatively impact efficiency improvements. Third, as seen above, human capital factors, including change management, play a critical role, as digitalization success depends on user proficiency, compliance, and trust. Fourth, while digitalization can be efficient, infrastructure reliability, including scanners, connectivity, etc., continues to be a major constraint, particularly in border regions. Last, but certainly not least, continued engagement with all relevant stakeholders remains critical to support private sector behavior with digitalization, as well as to sustain transparency. Overall, the above discussion serves to reinforce the earlier arrived at view that while the digital customs reforms undertaken by Nigeria amount to a positive move towards modern border management, the true potential thereof also depends on the complementary reforms undertaken at the institutional level. With the integration of technology, capacity-building initiatives, and governance, the digital customs reforms have the potential to move beyond the realms of an efficiency-driven approach to a cornerstone for transparent, competitive, and AfCFTA-

conducive trade facilitation.

6. Conclusion and Recommendations

6.1 Conclusion

The purpose of this study was to examine the progress of Nigeria with respect to the adoption of digital customs using the e-Customs (Trade Modernisation Project), and the National Single Window (NSW), and the findings suggest that the adoption of digital customs has resulted in moderate to significant progress with respect to the outcomes of trade facilitation at the Lagos Ports, Seme Border, and Onne Port. From the findings of this study, it can be stated that the adoption of digital customs resulted in significant progress with respect to the reduction of time spent for customs clearance at the ports of Lagos and Onne. However, the progress with respect to the Seme Border was moderate. In addition, the findings suggest that the adoption of digital customs resulted in moderate to significant progress with respect to the outcomes of customs revenue. In this respect, the progress was the most significant for the ports of Lagos and Onne. Further, the adoption of digital customs resulted in moderate to significant progress with respect to the reduction of corruption-related practices. In this respect, the adoption of digital customs resulted in the minimization of face-to-face interactions. In the future, it can be stated that the progress of Nigeria with respect to the adoption of the full maturity of the National Single Window and the question of whether the adoption of digital customs constitutes a transformative change or simply an evolutionary change remains to be seen.

6.2 Policy Recommendations

For the Nigeria Customs Service

Strengthen System Architecture and Integration: Upgrade the e-Customs and NSW platforms to ensure seamless interconnectivity with all regulatory agencies, port systems, and private sector logistics platforms. Full interoperability will minimise duplicate processes and improve end-to-end cargo visibility.

Enhance Risk Management Capabilities: Expand the use of data analytics and intelligence-led risk profiling to reduce reliance on physical inspections. Automating selectivity criteria will improve clearance speed while safeguarding revenue and compliance.

Invest in Continuous Capacity Building: Implement structured digital skills training for customs officers, focusing on system usage, data integrity, risk analysis, and ethical conduct. Strong human capacity is essential for sustaining digital reform outcomes.

Strengthen Performance Monitoring Systems: Institutionalise dashboards and performance indicators for clearance time, inspection rates, and system uptime to support evidence-based decision-making and accountability.

For Other Border Agencies

Improve Inter-Agency Integration and Data Sharing: Harmonise operational procedures and embed all relevant agencies—quarantine, immigration, standards, port authorities—within the NSW to reduce fragmentation and shorten processing intervals.

Promote Collaborative Enforcement Mechanisms: Establish joint operational centres or task teams to coordinate inspections, resolve bottlenecks, and ensure consistent application of digital procedures.

For Traders and the Private Sector

Strengthen Compliance with Digital Procedures: Encourage full utilisation of electronic documentation, pre-arrival processing, and online payments to reduce delays and increase system efficiency.

Promote Capacity Enhancement Programmes: Provide training and sensitisation programmes for freight forwarders, small-scale traders, and logistics operators to enhance digital literacy and reduce resistance to procedural changes.

Deepen Public-Private Collaboration: Create structured platforms for dialogue between customs, port operators, and trade associations to identify operational challenges, share feedback, and co-create solutions.

6.3 Limitations of the Study

While this study provides tremendous insights regarding the practical applications of "digital customs" across key trade lanes, some limitations have become apparent. Firstly, access to detailed data on customs operations, specifically detailed "time release studies" and revenue data, has been limited. Secondly, interviews with stakeholders have not always been possible, due to time and other limitations. Finally, it has become clear that, due to the nature and evolution of these reforms, some "digital customs" capabilities have not yet reached maturity. As these reforms continue to evolve, further evaluations are clearly necessary.

6.4 Suggestions for Further Research

The scope for further research lies in extending this analysis by conducting econometric evaluation for digital customs reforms. This will involve using high-frequency time series or panel data for clearance times, periods of cargo in transit, inspection rates, and revenue performance to establish causality and ascertain the degree of statistical significance for digital customs and NSW. This will provide further policy and case-based evidence for attributing efficiency and revenue gains to digital customs and NSW.

Furthermore, future work could also examine the welfare implications of digital customs transformation at the trader level, e.g., how faster clearance times, lower compliance costs, and greater predictability impact trader competitiveness, inventory management, and the participation of small and medium-sized enterprises in trade. Micro-level data, especially, could provide useful insights into the distributional impact of digitalization on different trader groups and border locations.

Moreover, future studies should focus on conducting cross-country comparative studies, particularly in ECOWAS countries, to compare differences in digital customs maturity, digital customs interoperability, as well as institutional coordination across member countries. In this regard, this line of study would be instrumental in gaining insights into regional integration issues, as well as best practices that can be used to develop harmonized digital customs systems that can support AfCFTA trade facilitation aspirations. Last but not least, longitudinal studies to observe the full implementation of Nigeria's NSW would be instrumental in gaining insights into long-term governance issues surrounding digital customs systems

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