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DIGITAL CUSTOMS TECHNOLOGY, OFFICER PERFORMANCE, AND TAX COLLECTION EFFICIENCY: A SOCIO-TECHNICAL INTEGRATION FRAMEWORK

Nurulhuda Mohammad[1]*, Norzaidi Mohd Daud[2]

[1]Faculty of Business and Management, Universiti Teknologi MARA, Malaysia
nurulhuda.mohammad@gmail.com https://orcid.org/0009-0008-8571-3515
[2]Faculty of Business and Management, Universiti Teknologi MARA, Malaysia
norza544@uitm.edu.my https://orcid.org/0000-0003-1641-8594
*Corresponding Author

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Abstract:

Digital transformation has become a key strategy for customs administrations aiming to improve tax collection efficiency while preserving service quality and meeting trade facilitation objectives. This thorough review compiles theoretical and empirical insights on the relationship between the implementation of digital customs technology and revenue outcomes, addressing the essential gap between technology investments and observable performance improvements. The research incorporates three complementary theoretical models: the Unified Theory of Acceptance and Use of Technology (UTAUT), the DeLone and McLean Information Systems Success Model, and Task-Technology Fit (TTF) theory. Utilizing literature from the Scopus and Web of Science databases (2010-2025), along with policy documents from the World Customs Organization, World Trade Organization, and Organisation for Economic Co-operation and Development, this review pinpoints four organizational enablers as vital factors in the effectiveness of customs technology: quality of training, user-friendly system design, ICT support infrastructure, and system integration. The analysis indicates that technology use acts as a mediating factor, affecting officer performance, thereby enhancing tax collection efficiency. This sequential mediation pathway offers a clear yet detailed explanation of how digital transformation drives revenue gains. The suggested integrated conceptual framework presents testable propositions that can be empirically validated through structural equation modeling. The practical implications are intended for customs leaders and policymakers in middle-income countries, particularly those engaged in regional integration efforts, such as the ASEAN Single

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Window, as well as administrations like the Royal Malaysian Customs Department.

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Delone And Mclean IS Success Model, Digital Customs, Officer Performance, Task-Technology Fit, Tax Collection Efficiency, UTAUT

Introduction

Efficient tax collection at national borders is essential for a state's effectiveness, financial health, and public trust (Besley & Persson, 2013; Bird, 2013). Customs administrations around the globe face the tough task of balancing several expectations: they need to facilitate legitimate trade, protect society from harmful goods, and generate crucial revenue through import duties and taxes. For many developing and middle-income countries, customs revenue accounts for a large share of total tax income, meaning that how well they perform at the border significantly affects a government's ability to support development efforts (Kokoli et al., 2021). Given the current circumstances, customs authorities are under pressure from finance ministries, international organizations, and the trading industry to improve their tax collection processes. It's essential that they do this while maintaining fairness, transparency, and a high standard of service.

To tackle these challenges, many customs authorities have turned to digital transformation as a vital strategy in recent years. This shift aims to better meet the diverse needs of all stakeholders involved. Many customs authorities are now using electronic declaration systems, national single windows, and advanced risk management tools to streamline processes. These innovations are intended to reduce clearance times, enhance compliance detection, reduce administrative costs, and boost revenue collection (McLinden, 2013; World Bank, 2018). International standards from organizations like the World Customs Organization (WCO) and the World Trade Organization (WTO) have further pushed governments to invest in digital customs systems as part of broader efforts to improve trade facilitation and modernize public services (World Customs Organization, 2017; World Trade Organization, 2017). Some early evidence suggests that countries implementing digital reforms can see benefits in revenue and

efficiency, but results can vary widely depending on the local context (Kokoli et al., 2021; UNCTAD, 2023).

Crucially, the relationship between technology deployment and tax collection efficiency is neither automatic nor guaranteed. Many customs administrations continue to experience revenue leakages, processing delays, and inconsistent enforcement outcomes despite substantial investment in digital tools. This persistent gap between technological potential and realized performance indicates that factors beyond hardware and software are operative. Emerging research and reform evaluations point to human capability, training quality, change management, system usability, ICT support, and inter-agency integration as decisive mediating conditions (DeLone & McLean, 2003; UNCTAD, 2023; World Customs Organization, 2017). From a management perspective, digital customs technology functions not merely as a technical artifact but as a sociotechnical system whose effectiveness depends on how leaders organize work, invest in skills, and govern data and processes (Goodhue & Thompson, 1995; DeLone & McLean, 2003).

Theoretical work on digital transformation in public administration has grown correspondingly sophisticated. Frameworks such as the Unified Theory of Acceptance and Use of Technology (UTAUT), the DeLone and McLean IS Success Model. Task-technology Fit (TTF) offers complementary perspectives on individual adoption, system quality, user satisfaction, and the alignment between tasks and technological functionalities (Goodhue & Thompson, 1995; DeLone & McLean, 2003; Venkatesh et al., 2003). Nevertheless, these perspectives have rarely been integrated into a coherent explanation of how digital customs technologies, organizational enablers, and officer performance interact to shape tax collection efficiency. The literature remains fragmented across information systems, public administration, taxation studies, and trade economics, with relatively few studies developing multilevel models that connect technology design, management practices, and fiscal outcomes in customs settings.

This article addresses these gaps through an integrated theoretical review of digital customs technologies to enhance tax collection efficiency. Drawing on narrative and scoping review methodologies, this synthesis presents evidence on four organizational enablers and links them to customs technology use, officer performance, and tax collection efficiency. Building on UTAUT, the IS Success Model, and TTF, the article proposes an integrated conceptual framework that highlights how management decisions on capability building, system design, and cross-agency interoperability influence the effectiveness of digital customs investments in generating revenue. The framework contributes by positioning digital customs reforms as a strategic management challenge within the public sector, providing a structured agenda for empirical research and managerial action in customs and tax authorities.

Review Methodology

This article employs a narrative and scoping review design to synthesize theoretical and empirical work on digital customs technology and tax collection efficiency. Narrative reviews are a great way to bring together insights from diverse fields like information systems, public administration, taxation studies, and trade economics. They allow for a thoughtful and conceptually rich synthesis of ideas, enabling a deeper understanding of how these different areas can connect and inform one another (Snyder, 2019). Scoping logic maps the breadth of existing evidence on customs digitalization, human and organizational enablers, and efficiency outcomes without restricting inclusion exclusively to narrow empirical designs (Arksey &

O'Malley, 2005; Levac et al., 2010). This combination supports the development of an integrated conceptual framework and propositions guiding future empirical work.

Search Strategy and Sources

Primary database searches were conducted in Scopus and Web of Science for the period 2010-2025. Search strings combined terms for digital customs and tax administration (e.g., "digital customs," "customs technology," "single window," "customs automation," "risk management system," "tax collection efficiency," "revenue mobilization") with filters for journal articles, books, book chapters, and high-quality conference proceedings. The search was complemented by targeted review of flagship policy reports from international organizations including the World Customs Organization (WCO), World Bank, International Monetary Fund (IMF), Organisation for Economic Co-operation and Development (OECD), and United Nations Conference on Trade and Development (UNCTAD), as well as regional initiatives such as the ASEAN Single Window and related documentation. These sources provide implementation-level evidence from customs administrations and technical details on data models, automation platforms, and time-release performance measurement.

In addition to the baseline coverage for 2010–2025, the search and source selection process also emphasized more recent evidence to ensure this synthesis aligns with the current phase of customs digitalization. In particular, meta-analyses, integrative reviews, and institutional reports published during 2021–2025 were prioritized when they describe the implementation mechanisms (e.g., organizational capacity, ICT support, system design, and interoperability) that influence technology adoption and officer performance. This prioritization is important, as the new wave of customs reforms increasingly relies on data integration, end-to-end workflow automation, and more detailed, evidence-based performance measurement.

Inclusion Criteria

Studies were included based on three main criteria. First, they addressed customs administration or closely related border tax functions rather than general inland tax administration. Second, they examined at least one of the following: digital customs technologies (such as single window systems, customs automation platforms, or risk engines); human and organizational factors influencing technology use (e.g., training, ICT support, user acceptance, system integration); or performance outcomes related to tax collection efficiency, compliance, or clearance times. Third, conceptual and theoretical papers, empirical studies (quantitative, qualitative, or mixed methods), and high-quality case studies or policy evaluations were considered, provided they offered explicit links between technology and performance outcomes. Only straightforward technical notes that did not include any analysis of performance implications were left out (Munn et al., 2018).

Synthesis Approach

The synthesis took place in three phases. Initially, descriptive mapping sorted studies by technology type, geographical region, methodology, and focus on outcomes, providing a summary of the evidence base and identifying gaps. Next, thematic analysis categorized the findings into four domains that consistently appeared in the literature: digital customs technologies and their efficiency results; human and organizational influences; theoretical approaches to technology adoption and overall system success; and integrated models that

connect technology, officer performance, and financial outcomes. Finally, insights from information systems theory were used as frameworks to integrate the findings into a unified conceptual model (DeLone & McLean, 2003; Goodhue & Thompson, 1995; Venkatesh et al., 2003; Tamilmani et al., 2021). During the discussions, it is worth highlighting insights from middle-income countries, as well as successful regional initiatives such as the ASEAN Single Window and Malaysia's National Single Window. These efforts are particularly important for customs administrations, including the Royal Malaysian Customs Department, which can benefit greatly from these developments.

Digital Transformation in Customs Administration

Core Technology Domains

In reviewing the literature, it is clear that four key technology areas are crucial to the digital transformation of customs. First, data standardization and single-window systems streamline information sharing. Next, customs automation platforms are making processes more efficient. Then there is the exciting potential of blockchain and smart contracts, which enhance transparency and security. Finally, artificial intelligence (AI) and advanced analytics are playing a significant role in optimizing operations and decision-making. Together, these technologies are shaping the future of customs in a big way. These technology domains cover the entire customs value chain from pre-arrival data submission and risk assessment through clearance, post-clearance audit, and performance monitoring, increasingly used in an integrated way instead of as standalone applications (UNCTAD, 2023; World Customs Organization, 2024).

Data standardization and single-window systems build on the WCO Data Model, which provides harmonized data elements and messages for cross-border regulatory processes and serves as a foundation for many national and regional single-window initiatives (World Customs Organization, 2023, 2024). The ASEAN Single Window (ASW) in Southeast Asia connects National Single Windows of member states for secure electronic exchange of customs and trade data, including preferential certificates of origin and the ASEAN Customs Declaration Document (Association of Southeast Asian Nations, 2020; Suvannaphakdy, 2022). Malaysia's National Single Window for Trade Facilitation, operated in collaboration with the Royal Malaysian Customs Department and Dagang Net, has been operational since 2009 and serves as a single gateway for traders to submit their regulatory documents electronically (Ministry of International Trade and Industry Malaysia, 2018; Dagang Net, 2024). These developments show how data standardization and single-window platforms can minimize documentation burdens, enhance data quality, and develop infrastructure for real-time risk management and revenue assurance.

Customs automation tools like ASYCUDA and national customs management systems offer end-to-end processing environments handling declarations, duty calculation, payment, and release. UNCTAD's ASYCUDA Programme documentation shows that modernized automation can reduce clearance times and increase revenue yields, especially when coupled with risk-based selectivity and post-clearance audit modules (UNCTAD, 2023). Blockchain and smart contracts are being piloted in selected corridors to create tamper-evident audit trails for high-risk supply chains, automate validation of licenses and permits, and support cross-border mutual recognition arrangements. While still emerging, these applications are positioned as complements to existing automation and single-window systems rather than

complete replacements (World Customs Organization, 2024). AI and advanced analytics support functions, including risk-based targeting, anomaly detection, text and image analysis, and predictive modeling for non-compliance. Recent work demonstrates machine-learning models' potential to improve hit rates in risk profiles and support more precise allocation of inspection resources (Vijayakumar, 2025), though data quality and human expertise remain decisive for real-world performance.

Table 1: Digital Customs Technology Domains and Efficiency Metrics

Technology Domain	Core Components	Primary Function	Efficiency Metrics
Data Standardization & Single Window	WCO Data Model v4, National Single Window, Regional integration (ASEAN SW)	Cross-agency interoperability, once-only submission	Clearance time, documentation costs
Customs Automation	ASYCUDA, ICMS, port-customs integration modules	End-to-end declaration lifecycle automation	Release time, processing volumes, error rates
Blockchain & Smart Contracts	Distributed ledgers, automated compliance verification	Immutable audit trails, event-driven release	Integrity assurance, AEO verification time
AI/ML & Advanced Analytics	Risk scoring, anomaly detection, NII image analysis, RPA	Predictive targeting, classification assistance	Hit rate, recovery yield, inspection ratio

Efficiency Metrics and Measurement Standards

Tax collection efficiency in customs contexts is assessed through a combination of revenue-related indicators and process-oriented performance measures. On the revenue side, standard metrics include the ratio of actual customs revenue to potential revenue, cost-to-collect ratios, audit hit rates, and yield from post-clearance audit and enforcement actions (Cantens et al., 2013; Kokoli et al., 2021). On the process side, the most widely recognized standard is the World Customs Organization's Time Release Study (TRS) methodology, which measures the time required for goods to move from arrival to release and is endorsed globally as a diagnostic tool for identifying bottlenecks and prioritizing trade facilitation reforms (World Customs Organization, 2018, 2025; Matsuda, 2011). TRS results are increasingly used to demonstrate the impact of automation, single-window systems, and coordinated border management on clearance performance.

In the ASEAN region, TRS and related time-based indicators have been applied alongside data on usage of the ASEAN Single Window and National Single Windows to evaluate improvements in border efficiency and trade facilitation. Evidence suggests that the live operation of the ASW has significantly increased the volume of electronic exchanges of

preferential certificates and customs declarations, contributing to faster processing and a more consistent application of preferential tariffs among member states (Suvannaphakdy, 2022; Association of Southeast Asian Nations, 2020). In Malaysia, the National Single Window (NSW) for Trade Facilitation and the subsequent digital customs initiatives are designed as tools to minimize the time and expenses involved in conducting business and to enhance trade competitiveness in accordance with the trade facilitation principles set by the WCO and WTO (Ministry of International Trade and Industry Malaysia, 2018; Dagang Net, 2024). For this overview, these metrics and standards are considered primary outcome constructs linking digital customs technologies and management practices to observed changes in tax collection efficiency and clearance performance.

Evidence on Technology-Efficiency Relationships

Evidence from case studies of different implementation contexts shows the relationship between digital customs technologies and efficiency gains. Measurable reductions in clearance times have followed ASYCUDA implementations in Timor-Leste, Tuvalu, Iraq, and Barbados, and have been paralleled by growth in customs revenue, with reported gains of 10-50% relative to pre-reform baselines (UNCTAD, 2023). There are many sources of these gains: automated validation, elimination of paper bottlenecks, better information on processing status, which leads to better resource allocation, and stronger audit trails aimed at discouraging informal revenue diversion.

At regional and advanced-economy levels, reforms such as the European Union's Import Control System 2 (ICS2) leverage sophisticated pre-arrival data analytics and machine learning techniques to improve risk profiling and enable faster, compliant trade. Data freely exchanged across borders by regional single-window integration in ASEAN has demonstrated documented improvements in documentary processing times. Nonetheless, realizing the full benefits will require ongoing investment in technical infrastructure and effective institutional collaboration (Suvannaphakdy, 2022). Meta-analyses of investment in digital government programs indicate that technological investments yield performance dividends, but effects are conditioned by organizational capacity, training provision, and management focus on change processes (Tamilmani et al., 2021; Dwivedi et al., 2020).

Despite the presence of positive cases, considerable variability in outcomes is reported in the literature. Poorly trained, isolated ICT, or cross-agency implementation frequently underperforms expectations, sometimes generating officer resistance and workarounds or parallel manual processes that deny an efficiency advantage (DeLone & McLean, 2003; UNCTAD, 2023). These patterns emphasize that deploying technology is necessary but not sufficient for improving tax collection efficiency, and they focus on the human and organizational enablers that will be examined in later sections.

The impact of technology on efficiency is also now confirmed by new evidence, but it is not automatic; it ultimately relies on the determination of organizations to “make technology work” in real-world work routines. Recent work on digital transformation in government has noted that it only leads to more successful digital initiatives if organizations focus on work process compatibility, data quality, user efficiency, and coordination among units and agencies; where these factors are weak, systems tend to produce minimal compliance, manual parallel work, or, at best, irregular activity. This pattern, in the context of customs, confirms the importance of

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training, ICT support, user-friendly design, and system integration as key conditions for translating technology investments into concrete operational results for the organization.

Theoretical Foundations

This part explores three theoretical models that together offer a thorough analytical basis for comprehending the adoption of technology, the success of systems, and performance results in custom settings: the Unified Theory of Acceptance and Use of Technology (UTAUT), the DeLone and McLean Information Systems Success Model, and the Task-Technology Fit (TTF) theory.

Unified Theory of Acceptance and Use of Technology

The Unified Theory of Acceptance and Use of Technology, developed by Venkatesh et al. (2003), summarizes eight principal models of technology acceptance into the most parsimonious framework. UTAUT delineates four central determinants of intention to use technology and behavior: performance expectancy (belief that using the system will improve job performance), effort expectancy (perceived ease of use), social influence (perception that important others believe the user should use the system), and facilitating conditions (organizational and technical infrastructure to support use). Meta-analytic evidence verifies that these constructs explain large variability in technology adoption across diverse contexts (Tamilmani et al., 2021). In public-sector customs institutions where technology use is generally mandated rather than voluntary, these constructs matter more. Performance expectancy remains predictive, as officers believe that systems enhance work efficacy and show greater engagement. Facilitating conditions become increasingly important in mandated settings, including training, infrastructure, and assistance that enable officers to use systems effectively, even when use is not discretionary. The four enablers identified in this review, which are quality of training, user-friendly system, ICT support, and system integration, align conceptually with UTAUT's facilitating conditions construct while providing greater specificity for customs contexts. UTAUT has been well validated across digital government and e-service use cases, with meta-analytic evidence confirming its robustness in defining technology use intentions and behavior (Tamilmani et al., 2021; Chan et al., 2023).

DeLone and McLean IS Success Model

The DeLone and McLean (2003) model identifies three quality dimensions as foundational There are three quality dimensions that form the basis for the theoretical framework of the DeLone and McLean (2003) model as antecedents of information system success: system quality (technical performance characteristics, namely reliability, response time, and usability), information quality (accuracy, timeliness, completeness, and relevance of outputs), and service quality (responsiveness and empathy of support services). These quality dimensions influence user satisfaction and intention to use, which in turn produce individual-level impacts that aggregate into organizational benefits. In a customs context, system quality includes platform reliability during peak processing periods, acceptable response times under load, intuitive navigation, and integration with related systems. Information quality refers to the accuracy of risk scores and classifications, the freshness of reference data, the completeness of shipment documentation, and the relevance of generated reports to decision-maker requirements. Service quality encompasses helpdesk responsiveness, problem-resolution quality, and cross-agency support coordination. The sequential pathway from enablers through usage to individual

performance to organizational efficiency illustrates the evolution of the D&M model from antecedents through use to net benefits. System quality, information quality, and service quality interact in ways that shape user satisfaction and use; both, in turn, shape net benefits in organizational environments (DeLone & McLean, 2003; Ojo, 2017).

Task-Technology Fit

The Task-Technology Fit theory, introduced by Goodhue and Thompson in 1995, suggests that performance improvements occur when the functions of technology correspond with the requirements of tasks. High fit is the degree to which systems enable capabilities and/or behaviors to align with the analytical, decisional, and operational needs associated with work tasks. Low fit results in workarounds, reduced utilization, and missed opportunities to capture potential productivity gains. In customs operations, task-technology fit involves aligning risk analytics modules with overall targeting decisions based on target strategies, supporting declaration processing workflows that comply with regulatory requirements, and enabling smooth data handoffs to audit and enforcement systems. Metaregression analysis confirmed that TTF predicts individual performance across diverse information system contexts, especially when systems support highly complex and data-intensive tasks (Jeyaraj, 2022; Muchenje & Seppänen, 2023). The enabler of system integration in the proposed framework explicitly addresses TTF concerns by ensuring technology capability and operational task compatibility. Task-technology fit in customs operations reflects the degree to which digital platforms facilitate officers' core functions, including risk profiling, valuation assessment, and post-clearance audit, with misalignment often arising as workarounds and usage disadvantages (Goodhue & Thompson, 1995).

Toward an Integrated Theoretical Lens

These three theoretical stances provide complementary, rather than competing, insights. Individual-level determinants of technology adoption are the focus of UTAUT, particularly in explaining why officers engage with systems at varying levels of intensity. The D&M model defines the quality dimensions that guide both adoption decisions and the value created in utilization. TTF shifts the emphasis from perceptions alone to a match based on objective criteria for technology characteristics relative to task demands. An integrated perspective positions the four organizational enablers as the main facilitators in customs technology usage: quality of training, user-friendly system, ICT support, and system integration. Technology use is the behavioral pipeline through which these enablers affect officer performance. Officer performance, in response, aggregates to organizational-level tax collection efficiency. This chain from enablers through usage and performance to efficiency is at the heart of the causal logic of the integrated framework developed in the following section. At a deeper level, the socio-technical view of digital government also emphasizes that technological success depends on the alignment of technical artifacts, human capabilities, organizational processes, and institutional rules (Begany & Gil-García, 2024).

Integrated Conceptual Framework

Based on the theoretical foundations and empirical findings discussed earlier, this section introduces a comprehensive conceptual framework outlining the causal relationship between organizational facilitators and the effectiveness of tax collection in customs environments. The

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framework combines UTAUT, DeLone and McLean's IS Success Model, and Task-Technology Fit into a unified model that includes propositional testability.

Model Structure

Figure 1 illustrates the integrated conceptual framework. The model finds four organizational enablers (Quality of Training, User-Friendly System, ICT Support, and System Integration) that are suggested to affect Customs Technology Usage. Subsequently, Technology Usage improves Officer Performance, which ultimately contributes to Tax Collection Efficiency. Therefore, both Technology Usage and Officer Performance serve as sequential mediators in the relationship between organizational enablers and Tax Collection Efficiency.

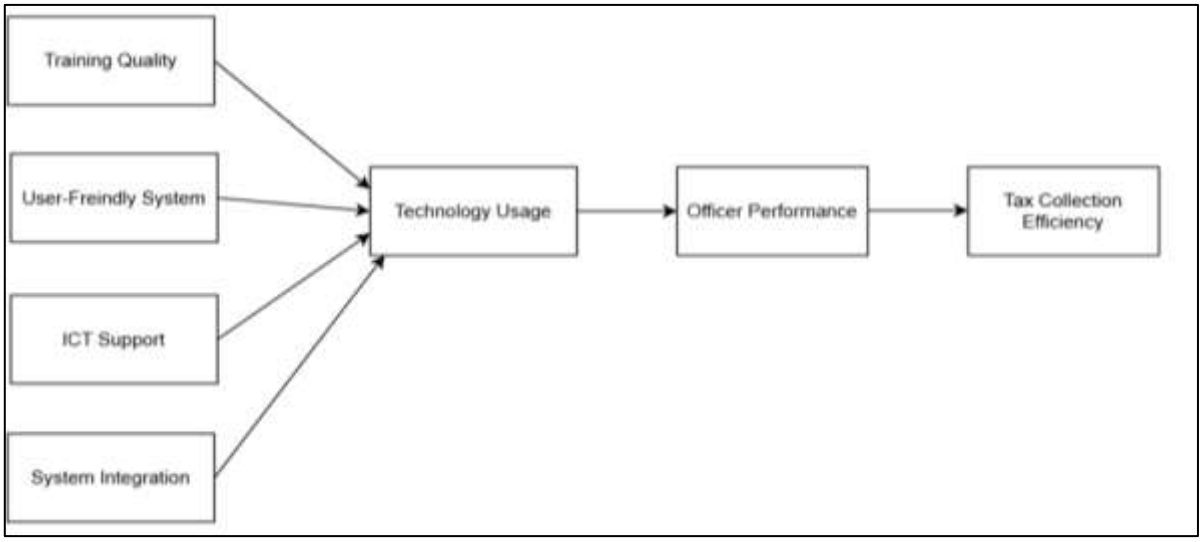

Figure 1: Integrated Conceptual Framework

Construct Operationalization

The framework operationalizes each construct with specific measurement indicators grounded in both theoretical and empirical foundations. Training Quality covers efficiency improvement (training helps achieve faster task completion), ease of learning (training enables understanding of system features), and leadership advocacy (management actively supports training initiatives). User-Friendly System captures task simplification (system reduces complexity of routine operations), effectiveness (system supports achievement of work objectives), and system clarity (interface design communicates functionality clearly).

ICT Support encompasses support availability (technical assistance is accessible when needed), productivity (support services facilitate efficient problem resolution), goal achievement (support infrastructure enables attainment of performance targets), and cultural norms (organizational culture values and prioritizes technical support). System Integration addresses compatibility (systems work effectively with other platforms and data sources), quality of output (integrated systems generate reliable, usable information), and job efficiency (integration reduces redundant effort and manual reconciliation).

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The use of technology in customs is evaluated based on the ease of learning (officers can easily develop the skills necessary to operate the system), reduced physical effort (technology lessens the need for manual labor), adaptability (officers can modify their use of the system to meet different operational needs), and value perception (officers see the advantages of using technology).

Officer performance is assessed through productivity (the amount of work completed), accuracy (the correctness of decisions and outcomes), job satisfaction (the favorable feelings about their work), and peer support (collaborative actions that assist colleagues in using technology).

Tax collection efficiency is measured by revenue growth (increases in tax collection relative to established baselines), processing speed (decreases in the time taken for clearance and assessment), and compliance rates (improvements in voluntary compliance and reductions in tax evasion).

Research Propositions

The integrated framework creates testable statements that outline directional relationships and mediation processes. In Table 2, these statements are displayed along with their theoretical foundations.

Table 2: Research Propositions and Theoretical Grounding

P#	Proposition Statement	Theoretical Basis
P1	Quality of Training positively influences Customs Technology Usage.	UTAUT: Facilitating conditions as a predictor of use
P2	A user-friendly system positively influences Customs Technology Usage.	D&M: System quality drives usage
P3	ICT Support positively influences Customs Technology Usage.	D&M: Service quality as an antecedent of use
P4	System Integration positively influences Customs Technology Usage.	TTF: Alignment drives utilization
P5	Customs Technology Usage positively influences Officer Performance.	D&M + TTF: Use produces individual impacts
P6	Officer Performance positively influences Tax Collection Efficiency.	D&M: Individual impacts aggregate to organizational benefits
P7	Customs Technology Usage mediates the relationship between organizational enablers (P1-P4) and Officer Performance.	Integrated: Usage as behavioral conduit
P8	Officer Performance mediates the relationship between Customs Technology Usage and Tax Collection Efficiency.	Integrated: Performance as a pathway to efficiency

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Construct Definitions and Measurement Roadmap

Table 3 presents conceptual definitions of the constructs within the framework, along with suggested measurement methods for empirical validation. The items provided are examples rather than a complete list; future studies should refine and confirm the measures for specific customs contexts.

Table 3: Construct Definitions and Measurement Indicators

Construct	Conceptual Definition	Measurement Indicators
Quality of Training	Effectiveness of training programs in developing skills for technology utilization	Efficiency improvement; Ease of learning; Leadership advocacy
User-Friendly System	The degree to which system design facilitates ease of use and task completion	Task simplification; Effectiveness; System clarity
ICT Support	Availability and quality of technical assistance for system users	Support availability; Productivity; Goal achievement; Cultural norms
System Integration	Degree of interconnection between systems enabling seamless data flow	Compatibility; Quality output; Job efficiency
Customs Technology Usage	Extent and quality of actual system use in performing customs operations	Ease of learning; Physical effort reduction; Adaptability; Value perception
Officer Performance	Individual-level effectiveness and productivity in customs operations	Productivity; Accuracy; Job satisfaction; Peer support
Tax Collection Efficiency	Organizational-level efficiency in collecting taxes with minimal cost and delay	Revenue growth; Processing speed; Compliance rates

This integrated framework frames training quality, user-friendly system design, ICT support, and system integration as major organizational levers for technology use and officer performance across UTAUT, IS success, and TTF perspectives (DeLone & McLean, 2003; Goodhue & Thompson, 1995; Venkatesh et al., 2003; Tamilmani et al., 2021). When included in broader regional and national digital initiatives such as the WCO Data Model, ASEAN Single Window, and Malaysia's National Single Window, they provide a coherent pathway to translate customs digitalization into measurable gains in tax collection efficiency (UNCTAD, 2023; Kokoli et al., 2021; Ministry of International Trade and Industry Malaysia, 2018).

Discussion and Synthesis

The comprehensive analysis and conceptual framework established in the earlier sections provide insights pertinent to both academic research and practical applications in customs administration.

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The Technology-Efficiency Nexus

A steady causal relationship appears across the examined evidence, linking organizational enablers to efficiency outcomes via intermediate behavioral and performance mechanisms. Digital infrastructure enables faster, more precise processing. However, this remains unrealized without complementary investments in human capability and organizational alignment. The usual conclusion that technology alone is not sufficient to achieve long-term efficiency gains also challenges technology-determinist views and highlights the fundamentally socio-technical context of customs modernization. The mediating role of customs technology use becomes more apparent in explaining contrasting results across implementations. When officers receive quality training, work with user-friendly systems, have access to responsive ICT support, and operate within well-integrated technological environments, they demonstrate higher, more effective use. This usage improves individual performance, which aggregates to organizational efficiency gains.

Human Capital as Critical Enabler

Training quality appears as perhaps the most consistent technology-enabled enabler of efficiency improvements. Well-structured training initiatives empower officers to work systems properly, interpret machine-generated algorithmic outputs appropriately, and exercise judgment in ambiguous situations. The increasingly widespread adoption of AI-backed risk tools compounds the importance of interpretive training; officers should know not just how to use systems but also when to trust, verify, or override these algorithms' recommendations. In addition to training, the ease of use of systems and the presence of ICT support shape technology outcomes. Performance management systems designed to support digital goals, recognition, and incentivizing mechanisms for effective technology adoption, and workplace environments characterized by supportive leadership, all contribute to long-term engagement with new systems. Disregard of these human factors in the face of advanced technological deployment can lead to suboptimal results. Recent developments in data-driven risk management also support the argument that interpretive training and operational support must move in tandem with the adoption of digital tools. In most administrations, the use of analytics and automation has increased; the challenge is no longer "using the system" but correctly interpreting system output, knowing when a decision needs to be amended, and ensuring that operational results align with compliance objectives and revenue collection goals. Thus, the value of ICT training and support lies not in core technical skills but in developing data-driven decision-making capabilities that directly influence officer performance and revenue generation, i.e., efficiency.

Sequential Mediation Pathway

The specification of sequential mediation involving technology use in customs and officer performance within the framework provides valuable analytical insights into how technology relates to efficiency. This pathway indicates that investing in organizational facilitators yields benefits not directly, but rather through their effect on how individuals engage with technology, thereby improving personal abilities that collectively contribute to organizational outcomes. This causal relationship has consequences for research design, suggesting that evaluations of practices should assess intermediate factors rather than focusing solely on direct relationships between enablers and efficiency; additionally, interventions should target specific linkages in the pathway where the potential for influence is greatest within specific contexts.

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Research Agenda

The analysis highlights multiple key focus areas for upcoming research to enhance both the theoretical framework and practical advice regarding customs modernization.

Empirical Validation of the Framework

The proposed theoretical framework needs to be empirically tested using survey designs and structural equation modeling (SEM) or partial least squares (PLS). Large-sample studies among customs officers can help estimate the strength of relationships between enablers and usage, usage and performance, and performance and efficiency. Such studies should use valid measurement tools tailored to the customs context, integrating perceptual survey items and available administrative performance data.

Causal Impact Evaluation

Most of the current evidence comes from studies that compare results before and after a program, or from reports that do not carefully account for what would have happened without the program. Future research should use methods that help draw clearer conclusions. Techniques like staggered difference-in-differences can look at different reform timings, synthetic control methods can create comparison groups from places that did not change, and regression discontinuity can use specific reform criteria. Using these methods would improve understanding of how certain digital interventions affect efficiency outcomes.

Measurement Development

Validated measurement instruments for key constructs, including training quality, user-friendly system design, ICT support, and system integration in customs contexts, remain scarce. Developing and validating survey instruments that connect perceptual measures to administrative performance metrics would enhance both academic research and practical application. The measurement framework outlined in Table 3 serves as an initial reference, but thorough psychometric studies are essential to confirm reliability and validity.

Cross-Regional Comparative Studies

Research that compares different regions and income levels can shed light on the most effective and scalable combinations of enablers and implementation strategies. Presently, the focus of evidence is on particular implementation settings, which restricts generalizability. Systematic comparative studies might reveal contextual boundary conditions and transferable success factors applicable across various administrative environments.

Priority Contexts and Testable Relationships

To increase the specificity of the research agenda, more studies in this direction should specify the situational context of the priorities, enabling “boundary conditions” to be empirically tested rather than merely conceptually discussed (Junquera-Varela et al., 2022; World Customs Organization, 2025). In contrast, low-income versus middle-income administrations, operational environments that prioritize border checks over post-clearance audits, and locations that vary in workflow complexity (high-traffic ports versus land corridors) are a few of the

context types that may deliver more powerful findings. Such contextual differences generally affect infrastructure limitations, levels of cross-agency integration, data accuracy, and levels of officers' training, and these will ultimately influence the quality of relationships in the proposed model (Junquera-Varela et al., 2022; World Customs Organization, 2025).

In this respect, the research agenda may be accelerated by developing more focused, potentially testable relationships, for instance, through multi-group analysis and moderated mediation testing. Some pertinent testing recommendations include: (i) Training Quality will have a stronger effect on Technology Usage in the case of a low capacity as the skills gap and a higher dependence on formal training are stronger; (ii) there is the strong expectation that System Integration will have a stronger effect on Tax Collection Efficiency through Technology Usage and Officer Performance if integration is through inter-agency interoperability rather than the internal integration; and (iii) the effect of Technology Usage on Officer Performance appears to be stronger in a post-release audit context, through audit productivity, case selection accuracy and revenue recovery rate, making the effect of Officer Performance on Tax Collection Efficiency stronger (OECD, 2024; Vijayakumar, 2025).

Moreover, it is suggested that studies be complemented with officer survey data, combined with administrative indicators (e.g., release times, audit outcomes, case cycle times, recovery rates, or Time Release Study metrics) to improve reliability and reduce common-method bias. Developing such an approach yields more usable, applicable results that can be transferred to implementation practices across various administrative contexts (World Customs Organization, 2025).

Practical Implications

There are practical implications for the integrated framework developed in this article beyond the above. Customs leaders, tax policymakers, and public sector managers who help manage digital transformation. It emphasizes that efficiency in the tax collection process is not limited to adopting sophisticated systems but also to managers' arrangements for training, system design, ICT support, and inter-organizational integration. For governments like the Royal Malaysian Customs Department and similar agencies in middle-income economies, the framework translates into tangible levers for management and investment priority areas (Kokoli et al., 2021; World Customs Organization, 2017; UNCTAD, 2023).

Investing in Training Quality

The framework recognizes training quality as a strategic rather than a mere operational tool. Managers may wish to design recurring, task-specific training programs that, beyond mere principles of system navigation, should aim to drive risk management, analytics-based decision-making, and the interpretation of system-generated alerts. Training curricula must align with evolving business operations and regulations and include detailed learning objectives linked to performance indicators. Classroom-based impact can be reinforced by management through collaboration, on-the-job training, digital learning, real-life data and cases, and the infusion of coaching and peer-learning mechanisms. Leadership advocacy for continuous professional development in career development, which entails formal recognition and incentivisation of skill development, indicates that mastering digital tools contributes to both professional outcomes and career advancement (World Customs Organization, 2017; UNCTAD, 2023).

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Enhancing System Usability

Managers should treat usability as a primary design requirement. Involving front-line officers, supervisors, and brokers in co-designing the interfaces, workflows, and technology often surfaces pain points and task-system misalignments early in development cycles. Iterative testing, user feedback loops, and pilot deployments offer low-cost opportunities to test user interfaces, screens, data fields, and process flows before moving to full-scale implementation. Tactical measures such as simplifying data entry steps, providing contextual help, standardizing error messages, and ensuring consistency across modules can significantly reduce cognitive load and error rates. When system enhancements are explicitly couched as responses to officer feedback, they foster a sense of trust and ownership, which positively impacts adoption rates too (Goodhue & Thompson, 1995; DeLone & McLean, 2003).

Strengthening ICT Support

The framework identifies ICT support as part of a visible commitment to digital transformation. The support arrangements must be responsive; thus, managers must ensure they are accessible and tailored to operational realities, such as 24/7 border operations. This includes setting clear escalation paths, defining service-level expectations, and monitoring support performance by metrics that represent user experience in addition to system uptime. Blending centralized ICT helpdesks with local "super users" or champions within key operational units can shorten resolution times and foster informal learning networks. Regular reporting on everyday issues, root-cause analyses, and feedback to system development teams can transform support data into a strategic resource for continuous improvement (DeLone & McLean, 2003; Ojo, 2017).

Improving System Integration

The framework stresses that system integration is a managerial and institutional undertaking as much as it is a technical one. Customs leaders and policymakers need to actively negotiate data-sharing agreements, harmonize procedures, and align key performance indicators with partner agencies, including tax authorities, ports, banks, and licensing bodies. Establishing governance structures for inter-agency integration, such as steering committees, working groups, and technical task forces, can also help maintain momentum to resolve disputed data ownership or process changes (World Customs Organization, 2017; McLinden, 2013). For administrations progressing toward a National Single Window or similar platforms, phased integration strategies with defined milestones and risk mitigation plans are critical (UNCTAD, 2023; World Bank, 2018). Integration activities will be more attractive if closely coordinated to measurable gains in audit effectiveness, voluntary compliance, and revenue performance, attracting continued political and budgetary support (Kokoli et al., 2021; World Bank, 2018).

Conclusion

This structured theoretical review focuses on designing approaches to implement digital customs technology to improve tax collection efficiency, with a specific focus on organizational enablers that influence technology outcomes in practice. Governments and international organizations increasingly urge electronic declarations, single-window systems, and advanced risk engines as solutions to challenges in revenue and trade facilitation; this article has argued that supporting such technologies will only realize their potential when embedded within supportive management practices (Bird, 2013; World Customs Organization,

2017). By integrating findings from various information systems, public administration, taxation, and trade literature, the review frames digital customs reform as a transformation that involves both sociotechnical and managerial aspects, rather than merely a technical enhancement. (Goodhue & Thompson, 1995; DeLone & McLean, 2003).

The paper adds to theory by considering the Unified Theory of Acceptance and Use of Technology, the DeLone and McLean IS Success Model, and Task-Technology Fit within a consistent framework for customs and tax administration contexts (Goodhue & Thompson, 1995; DeLone & McLean, 2003; Venkatesh et al., 2003). The proposed model emphasizes four organizational enablers: quality of training, user-friendly interface design, ICT support, and system integration, and traces their influence through customs technology usage and officer performance related to tax collection efficiency. This multi-level view extends previous research by linking individual adoption and system quality constructs to organizational and fiscal outcomes, providing deeper insight into why similar technologies can produce different results across administrations (Besley & Persson, 2013; Kokoli et al., 2021).

To guide the future, the propositions derived from the framework serve as a structured agenda for empirical work investigating pathways and testing mediating and moderating effects, as well as for scaling the model to other public-sector settings. From a management and practice perspective, the framework provides a roadmap for customs leaders and policymakers seeking to convert digital investments into sustainable revenue. It explains that strategic investment in training, an effortful focus on usability, strong ICT support services, and purposeful agency integration are not optional but fundamental performance determinants (DeLone & McLean, 2003; UNCTAD, 2023; World Customs Organization, 2017). For senior managers, the model can inform the design of reform programs, the allocation of resources, and the selection of key performance indicators to monitor technology usage and revenue outcomes (World Bank, 2018). For frontline supervisors, it offers levers such as coaching, feedback, and local problem-solving to enhance officers' competence and motivation to use digital tools effectively.

At the same time, the review highlights that the proposed framework is conceptual and preliminary and therefore relies on secondary evidence. Constructs should be operationalized in future research; robust measurement tools for officer effectiveness and tax collection efficiency in digital customs environments should be developed; and the model should be evaluated through quantitative studies and mixed-method designs. Comparing cross-country, by income level, and by reform path would be particularly useful for evaluating model generalizability and uncovering contextual contingencies. Despite these limitations, the article makes a timely and practical contribution by reshaping digital customs technology as a management practice challenge at the intersection of information systems, public sector performance, and tax administration (Bird, 2013; Besley & Persson, 2013). For researchers and practitioners concerned with public-sector digital transformation, the framework also presents a novel perspective on how organizations can design, govern, and use digital technologies to strengthen state capacity and mobilize revenue (Kokoli et al., 2021; World Bank, 2018).

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