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DIGITAL TRANSFORMATION OF AIR CUSTOMS CLEARANCE. A STUDY ON REDUCING DELAYS THROUGH TECHNOLOGY

Mr. B. ASWIN[1], Ms. P.C. SARANYA[2]

II MBA SHIPPING AND LOGISTICS MANAGEMENT DEPARTMENT OF MANAGEMENT STUDIES,

VELS INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES, CHENNAI -117[1]

ASSISTANT PROFESSOR –MBA SHIPPING AND LOGISTICS MANAGEMENT

VELS INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES, CHENNAI -117[2]

Abstract: The digital transformation of air customs clearance processes has emerged as a critical solution to reduce delays, enhance efficiency, and improve the overall operational effectiveness of international trade. This study explores the role of advanced technologies such as automation, artificial intelligence (AI), block chain, and data analytics in optimizing air cargo clearance systems. By replacing traditional, paper-based methods with digital systems, customs authorities can significantly decrease clearance times, mitigate human error, and improve transparency. This research analysis the integration of these technologies into existing frameworks and assesses their impact on reducing bottlenecks, improving data accuracy, and streamlining communication between stakeholders. Furthermore, the study examines case studies from various airports and customs authorities that have successfully implemented digital tools, highlighting the challenges faced and the benefits realized. Ultimately, the paper aims to propose actionable strategies for policymakers, customs officers, and stakeholders to accelerate the adoption of digital solutions in air cargo customs clearance, thereby contributing to global supply chain efficiency and reducing overall logistics costs.

Keywords: Digital transformation, Air customs clearance, Automation, Artificial intelligence, Block chain, Data analysis, Supply chain, Customs automation.

I. INTRODUCTION

In today's globalized world, air cargo plays a pivotal role in the movement of goods across borders, facilitating international trade, supply chains, and economic development. The rapid movement of goods via air transport is essential, particularly for time-sensitive industries such as electronics, pharmaceuticals, perishable goods, and e-commerce. However, despite its advantages in speed and reliability, one significant challenge facing the air cargo industry is the delay in customs clearances at airports. These delays can have wide-ranging effects, causing disruptions in supply chains, increasing operational costs, and adversely affecting customer satisfaction.

Customs clearance, the process by which goods are inspected, documented, and authorized to enter or exit a country, is an essential but often cumbersome part of air freight logistics. Traditional customs procedures typically involve complex, manual documentation, physical inspections, and various forms of communication between customs authorities, freight forwarders, and other stakeholders. These traditional practices not only contribute to inefficiencies but also introduce considerable delays, especially when volumes of cargo are high, as is often the case in busy air ports. As the global demand for faster delivery times continues to rise, these delays have become increasingly untenable.

Freight forwarders are an essential part of the customs clearance process. They are responsible for arranging and coordinating the shipment of goods, including ensuring that all required documentation is in order and that the shipment is in compliance with regulations. Freight forwarders can act as intermediaries between the shipping company, CBP, and the importer, and can help to alleviate some of the complexities involved in customs clearance.

Block chain offers a decentralized and tamper-proof system for managing trade documentation and transaction history. Ensures data immutability—records cannot be altered once entered.

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Improves transparency and traceability of goods from origin to destination. Helps prevent document fraud, under-invoicing, and misdeclaration. Smart contracts can automate release or clearance based on pre-set compliance conditions.

IoT involves embedding sensors and tracking devices in containers and cargo. Real-time monitoring of cargo location, temperature, humidity, and tampering. Useful for customs in overseeing the transit of perishable, hazardous, or high-value goods Supports compliance with handling and storage regulations, especially for pharmaceuticals and food products

II. REVIEW OF LITERATURE

H.Y. Lam & Valerie Tang (2023) This study explores the application of Robotic Process Automation (RPA) in enhancing cold chain management within the freight forwarding industry. Focusing on Chevalier AOC Freight Express Holding Limited, the authors identify inefficiencies in manual data handling, particularly concerning temperature-sensitive shipments. Two RPA bots, Bot-Status and Bot-Temperature, were developed to automate the extraction of shipment status and temperature data, respectively. These bots interface with airline cargo websites and internal databases to provide real-time updates, ensuring that temperature-controlled shipments maintain their integrity throughout transit. The automation led to reduced manual workload, minimized errors, and improved response times. This case underscores the potential of RPA in optimizing cold chain logistics, ensuring compliance with stringent quality standards, and enhancing overall operational efficiency.

Georgi Nalbantov, Dimitar Todorov, Nikolay Zografov, Stefan Georgiev, Nadia Bojilova (2021) This paper introduces the Predictive Maintenance Tool for Non-Intrusive Inspection Systems (PMT4NIIS), designed to enhance the reliability of X-ray security systems used in customs inspections. Recognizing the critical role of these systems in ensuring border security and the economic implications of their downtime, the authors developed an AI-driven platform that provides real-time warnings of potential system malfunctions. By continuously monitoring system performance, PMT4NIIS enables preemptive maintenance actions, thereby reducing unexpected downtimes. The tool's deployment has led to improved operational efficiency, ensuring that customs inspections remain uninterrupted and effective. This study underscores the value of integrating predictive analytics into maintenance protocols to bolster the resilience of critical inspection infrastructure.

Jia Hao Tan & Tariq Masood (2021) This study delves into the adoption of Industry 4.0 technologies within airport operations, emphasizing the challenges and success factors associated with such digital transformations. Through a comprehensive survey of 102 airport operators and managers worldwide, the research identifies key obstacles, including technological integration issues, organizational resistance, and environmental constraints. The study employs the Technology-Organization-Environment (TOE) framework to analyze these challenges systematically. Findings highlight that while the potential benefits of digital technologies—such as enhanced operational efficiency and improved passenger experiences—are well-recognized, their implementation varies significantly across airports. Success factors identified include strong leadership commitment, employee training, and collaboration with technology providers. The research underscores the importance of a holistic approach, considering technological readiness, organizational culture, and external environmental factors, to successfully implement digital solutions in airport settings.

Edwin Orlando Curtidor Juárez (2024) Guatemala's Superintendency of Tax Administration (SAT) embarked on a comprehensive modernization of its customs processes, particularly focusing on air cargo clearance. Recognizing that air transport, despite its speed, suffered from prolonged clearance times, SAT introduced a new model emphasizing digital transformation. Central to this initiative was the implementation of the Alfresco IT system, a robust document management platform facilitating seamless information exchange via blockchain technology. This system allowed stakeholders, including airlines and customs officials, to publish and access electronic air waybills (e-AWB) and other pertinent documents in real-time. Additionally, machine learning models were integrated to automate manual processes and enhance risk identification. The "Virtual Agency," a user-friendly web interface, was developed to ensure accessibility for both public and private entities. Training sessions were conducted to familiarize users with the new digital services. The results were significant: since the model's launch in January 2024, there has been a 74% reduction in average clearance times for air cargo compared to 2019, even with a 14% increase in operations. The system also improved targeting capabilities, leading to more tax adjustments and seizures. Economic operators benefited from real-time tracking and reduced time spent in temporary customs warehouses. This case exemplifies how strategic digital interventions can streamline customs processes, reduce delays, and enhance overall efficiency.

Mac Sullivan, Johannes Kern(2021) The topic of this thesis is digital transformation of air cargo, and this research aims to identify drivers and barriers of change as well as solutions for the future.

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Main themes of this research have been visible in form of new innovations, articles and researches as well as from an industry bodies such as IATA, for some years now. There have been efforts within the air cargo industry to move towards a more digital world, but still adaptation lags behind and funding is limited. At the same time e-commerce and COVID-19 are transforming the air cargo industry with challenges requiring rapid changes. Literature review of this research consists of knowledge on air cargo and air cargo supply chain, first providing knowledge of the value of air cargo, forces and constraints for growth followed by introduction the common concepts, processes and stakeholders. Most importantly, literature review explains the data transfer within the air cargo supply chain and provides some examples of future digitalization of the air cargo industry. Literature review is based on industry articles and researches conducted. Research methodology consists of qualitative in-depth interviews conducted with aviation industry professionals, with decades of experience from different parts of the air cargo supply chain. Interviews were conducted during the fall of 2020 and sample size for this research was five participants. Based on the results from the interviews, the most common drivers of change were the rapid rise of e-commerce and the current COVID-19 pandemic. Most notable problems were fragmentation of the supply chain as well as lack of funding for new innovations and developments. However, also solutions for these problems were identified in forms of data- sharing and collaboration. These factors create many opportunities and the literature review of this report introduces the shift from traditional EDI systems used in air cargo into APIs as the enables of collaborative supply chains of the future. Data sharing being one primary solution as it hosts major opportunities in the shift from fragmented arcanely lead industry into transparent and collaborative future. In aim for a brighter future and digital transformation, air cargo industry has seen global standards set, partnerships created and innovations formed.

Floris de Haan ,Merten Nefs(2024) In the increasingly digital world we currently find ourselves in, e-commerce continues togrow. Transportation of e-commerce goods requires a different approach of operating thantraditional logistics. This exploratory study focuses on gaining an in-depth understandingof the impact of the e-commerce goods flow on the efficiency and effectiveness of customsclearance at airports, with a focus on order processing activities in both an integratedand traditional supply chain. Eight semi-structured expert interviews in the field ofair cargo, e-commerce, logistics integrators and/or customs clearance are conducted togain insight into the different perspectives of this supply chain. On the consumer side, research has been conducted into consumer satisfaction of e-commerce shipping companies,with a sample of 110 participants. Although there is little literature on the influence of e-commerce order process activities on customs clearance at airports, the study shows that indeed collaboration can increase efficiency, which is in line with the literature on supply chain integration. This study indicates that e-commerce order processing significantly influences the efficiency and effectiveness of customs clearance, due to high volumes and lack of sufficient data sharing.

MATEC Web Conf (2021) The last years' experience of functioning during the COVID-19 pandemic has shown that digital solutions can significantly increase the efficiency of business operational processes. This study focuses on the implementation of digital technologies at the airports to optimize information and financial flows, that are required for the air cargo transportation. The study was carried out based on the analysis of technological schedules of airports and airlines for cargo handling. As a result of this study, we have identified the main problematic operations leading to an increase in the time spent by cargo at the airports. The article examines and summarizes the world practice of using blockchain technology to manage information and financial flows in air cargo. The article has developed a model for the implementation of these technologies in the air cargo industry on the basis of a single blockchain platform. This model allows making optimal use of available airport resources in order to minimize service delays. It solves the main problem of creating the transparency of the information exchange between all air cargo transportation participants.

Wee Kwan Albert Tan, Balan Sundarakani (2020) The purpose of this study is to develop a framework for a freight consolidation company to adopt blockchain for the shipping community. Our research critically examine the challenges faced by a global shipping company that offer freight consolidation businesses and explore the use of Blockchain technology to enhance the competitiveness and sustainability of freight booking operations.This paper is a case study, ECU Worldwide, with focus on transforming their operations using blockchain technology for the freight booking industry. As the case is explorative in nature, the research aim to unearth the complex blockchain adoption phenomenon in the industry as the technology is very nascent at present. The research is primarily grounded on Technology Acceptance Model (TAM) theory.

SCOPE OF THE STUDY

- To Identify the Key Causes of Delays in Air Customs Clearances.
- To Evaluate the Effectiveness of Current Digital Solutions.
- To Analyses the Barriers to Full Digital Adoption.
- To Propose Digital Innovations and Strategies for Process Optimization.

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- To Examine the Impact of Digitalization on Efficiency and Speed.
- To Assess the Economic and Operational Benefits of Reduced Delays.

NEED OF THE STUDY

The increasing volume of international air cargo has placed immense pressure on traditional customs clearance processes, often leading to significant delays, increased costs, and inefficiencies. With global trade becoming more time-sensitive, there is a growing need to modernize and streamline customs operations. Digital transformation offers a powerful solution by enabling faster data processing, better coordination among stakeholders, enhanced transparency, and real-time tracking of shipments. Studying the application of technology to air customs clearance is crucial for identifying ways to reduce bottlenecks, ensure compliance, and boost overall trade competitiveness. This research is essential to understand how digital tools such as automation, artificial intelligence, block chain, and electronic documentation can revolutionize customs practices, minimize human error, and create a more efficient and resilient supply chain ecosystem.

OBJECTIVES OF STUDY

PRIMARY:

To evaluate how digital transformation in air customs clearance can reduce delays, enhance efficiency, and improve overall trade facilitation through advanced technologies such as automation, artificial intelligence (AI), block chain, and data analytics.

SECONDARY

1. Identify Key Challenges and Examine the primary causes of delays in air customs clearance, including manual processing, and lack of integration between stakeholders**.**

2. To Analyses how digital transformation can improve trade flows, reduce costs, and enhance compliance with international regulations.

3. Investigate successful implementations of digital customs clearance systems in various countries and their impact on efficiency.

4. To Provide actionable recommendations for customs authorities and logistics companies to implement technology-driven solutions for faster clearance.

III. RESEARCH METHODOLOGY

According to Clifford Woody "Research comprise defining and redefining problems formulating hypothesis or suggested solutions, collecting/organizing and evaluating data making deduction & research conclusions and at last carefully testing the conclusion to determine whether they fit the formulation hypothesis.

Methodology denotes a specific method of collection and analysis of data. It is a way to systematically solve the problem. It is necessary for the researcher to know not only the research methods/techniques but also the methodology.

Research methodology refers to the systematic process followed by researchers to conduct a study or investigation. It outlines the steps, procedures, and techniques used to gather, analyse, and interpret data in order to answer research questions or achieve research objectivesIt encompasses the overall framework for planning, executing, and evaluating research projects, guiding researchers in their pursuit of answering research questions or achieving research objectives. Research methodology involves decisions regarding research design, data collection methods, sampling techniques, data analysis procedures, and ethical considerations, all aimed at ensuring the validity, reliability, and ethical integrity of the research process and outcomes**.**

RESEARCH DESIGN

The research design refers to the overall plan for conducting the research. It includes the type of research, the research questions, the data collection methods, and the data analysis techniques. The research design should be carefully planned and tailored to the specific research question being addressed.

It outlines the structure, framework, and procedures for collecting and analysing data to address research questions or objectives effectively. Research design encompasses various elements, including the type of research (e.g., qualitative, quantitative, mixed-methods), the selection of research participants, the sampling strategy, the data collection methods, and the data analysis techniques. A well-defined research design ensures that the study is conducted systematically, rigorously, and in accordance with the goals of the research, allowing researchers to generate meaningful findings and draw valid conclusions.

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SAMPLING TECHNIQUES

SNOWBALL SAMPLING

In Snowball sampling, Researchers Begin with a small group of known individuals (Called seeds) Who meets the criteria for the study. These individuals are then asked to refer other people they know who also meet the study criteria. This process continues, forming a chain of referrals-just like how a snowball grows as it rolls and collects more snow.

CONVENIENCE SAMPLING

Convenience sampling is a non-probability sampling method where the researcher selects participants who are easily accessible and willing to take part in the study. It is often used when time, cost, or accessibility limits the ability to use more rigorous sampling techniques. While convenient and quick, this method may not represent the larger population accurately and can introduce bias

METHODS OF DATA COLLECTION

The **methods of data collection** used in the project *"Digital Transformation of Air Customs Clearance: A Study on Reducing Delays through Technology"* are described in **Chapter 3 – Research Methodology**, specifically under section **3.5 Methods of Data Collection**.

From the context provided throughout the document, the **main method of data collection** is through a **structured questionnaire**. This is confirmed by section 3.4, which explains that a structured questionnaire was used to gather consistent and comparable data from customs officers, freight forwarders, and airline staff. These questionnaires were designed to include primarily **closed-ended questions** (such as multiple choice, Likert scales, etc.) to facilitate **quantitative analysis**.

Additionally, the study employed:

- **Snowball Sampling** and **Convenience Sampling** techniques (section 3.3) to select participants.
- The questionnaire targeted different stakeholders in air customs processes, allowing the researcher to capture diverse perspectives on the impact of digital transformation.

ANALYSIS:

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	34.521[a]	12	<.001
Likelihood Ratio	27.840	12	.006
Linear-by-Linear Association	.264	1	.607
N of Valid Cases	56		

17 cells (85.0%) have expected count less than 5. The minimum expected count is .07.

Null Hypothesis (H_0):

There is **no significant association** between the type of digital coordination challenge and the type of technological bottleneck experienced.

Alternative Hypothesis (H_1):

There **is a significant association** between digital coordination challenges and technological bottlenecks.

INTERPRETATION:

The analysis shows a **statistically significant relationship** (**p < .001**) between digital coordination challenges and technological bottlenecks in air cargo clearance. Specifically, coordination issues such as continued use of paper-based systems or airport access restrictions are **strongly linked** to bottlenecks like **inconsistent ICEGATE server responses** and **manual delays**.

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IV. FINDINGS

The survey, conducted among **58 respondents**, assessed key challenges, perceptions, and recommendations related to **ICEGATE (Indian Customs Electronic Gateway)** in export-import processes. Below is a consolidated summary of the findings:

1. Awareness of ICEGATE's Primary Role

- **62.1%** correctly identified electronic filing of customs documents as ICEGATE's primary function.
- **38%** had misconceptions (e.g., licensing exporters, cargo verification, warehousing).
- **Key Insight**: Need for awareness campaigns to clarify ICEGATE's role in digital documentation.

2. Technical Challenges in ICEGATE Usage

System Performance Issues

- **70.7%** cited **system downtime/delays during peak hours** as the top issue.
- **63.8%** reported **disruptions due to frequent software updates**.
- **58.6%** highlighted **inconsistent server responses** affecting real-time updates.

Integration Barriers

- **65.5%** of freight forwarders complained about **lack of APIs for workflow automation**.
- **56.9%** noted **integration failures with airport cargo handling systems** as a major hurdle for airlines.
- **64.9%** of customs brokers rely on **manual backups due to ICEGATE crashes**.

Document-Specific Delays

- **69.9%** identified **shipping bills** as most affected by system glitches.
- **56.9%** blamed delays in **RMS (Risk Management System) alerts** for clearance bottlenecks.

3. Sector-Specific Pain Points

For Airlines

- **64.9%** faced **EDI format mismatches** during ICEGATE integration.
- **68.4%** emphasized **continued use of paper-based airway bills** as a digital coordination hurdle.

For Logistics Providers

- **60.3%** struggled due to **lack of real-time status updates**.
- **58.6%** flagged **duty drawback claim filing** as insufficiently automated.

V. SUGGESTIONS

Based on the survey responses from 58 participants, the following detailed recommendations are proposed to enhance **ICEGATE (Indian Customs Electronic Gateway)** and improve its functionality, usability, and efficiency for various stakeholders such as exporters, importers, logistics providers, and customs brokers.

1. Ensure ICEGATE runs smoothly, minimizing downtime and delays, especially during peak submission hours, and providing real-time updates for timely decision-making.

Recommendations:

- ICEGATE should invest in upgrading its server infrastructure to handle large traffic volumes and reduce downtime. Using cloud-based or hybrid solutions that scale with demand could ensure smooth operations during peak periods.
- Update schedules should be planned during off-peak hours, and ICEGATE can implement staging environments for software updates to test compatibility before going live. A robust rollback mechanism should be in place in case of critical issues.
- ICEGATE should integrate real-time tracking systems with customs clearance, providing instant status updates for shipments, cargo clearance, and other relevant data to keep stakeholders informed.
- ICEGATE should streamline the Risk Management System (RMS) to generate timely alerts and notifications for clearance issues, making it more proactive in addressing potential bottlenecks.

2. Automate key processes, reduce manual intervention, and enhance the digital experience to ensure faster, more efficient operations for customs procedures.

Recommendations:

Automating the duty drawback claim process would eliminate human errors, speed up claims processing, and reduce dependency on manual paperwork.

ICEGATE should open up more APIs to integrate seamlessly with logistics and customs systems, facilitating end-to-end automation of documentation, submissions, and clearance processes.

Block chain technology can be used to implement electronic Air Waybills (e-AWB), ensuring greater transparency, security, and traceability in air cargo transactions.

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ICEGATE should push for a full transition to electronic airway bills, removing paper-based documentation and enabling faster, more efficient processing.

VI. CONCLUSION

This research undertaken at Ever Shine Logistics over a period of three months provides critical insights into how digital transformation is reshaping air customs clearance processes in India. With the growing complexity and volume of global trade, traditional customs clearance methods—largely reliant on manual processes—are increasingly inadequate to meet the speed, accuracy, and transparency demanded by modern supply chains. The findings of this study affirm that embracing advanced technologies such as automation, artificial intelligence (AI), block chain, and real-time data analytics is essential for reducing procedural delays, enhancing efficiency, and improving trade facilitation.

The study's primary objective—to evaluate the role of digital transformation in minimizing delays and strengthening operational efficiency—was met through data collection, stakeholder interaction, and comparative analysis. It was found that the majority of delays stem from fragmented systems, limited integration among logistics stakeholders, paper-based documentation, and outdated legacy platforms.

Through secondary objectives, the study explored how the application of technologies like AI-driven risk assessment, block chain-enabled document verification, and automated duty drawback filing can revolutionize air customs clearance. Case studies of international best practices, such as those implemented in Singapore, South Korea, and the Netherlands, demonstrated significant improvements in clearance times, cost reductions, and compliance levels through digital innovation.

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