



STREAMLINING INDONESIA'S NATIONAL LOGISTICS ECOSYSTEM: A STRATEGIC INTEGRATION OF CUSTOMS AND CROSS-SECTOR STAKEHOLDERS USING DISRUPTIVE TECHNOLOGY FOR SMART TRACK AND TRACE LOGISTICS SYSTEM

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ARTICLE INFORMATION

ARTICLE HISTORY

Received
02 September 2024

Accepted to be published
31 December 2024

KEYWORDS:

Logistics
System
Digital
Track and trace,
National logistics ecosystem

ABSTRACT

Sektor logistik Indonesia menghadapi tantangan signifikan akibat fragmentasi dan kurangnya integrasi antara layanan logistik yang disediakan oleh berbagai instansi pemerintah. Sistem Nasional Track & Trace Logistik sangat penting bagi Ekosistem Logistik Nasional, karena meningkatkan efisiensi distribusi, memajukan digitalisasi, dan mendorong kolaborasi antara sektor publik dan swasta. Tujuan dari penelitian ini adalah untuk mengidentifikasi dan mengeksplorasi potensi integrasi sistem Track & Trace Nasional dengan berbagai teknologi digital, sehingga menciptakan platform yang koheren dan kolaboratif untuk meningkatkan efisiensi operasional. Penelitian ini menggunakan tinjauan pustaka dalam pendekatan penelitian kualitatif, dengan metode pengumpulan data sekunder. Temuan penelitian menunjukkan bahwa dengan mengintegrasikan teknologi API, kode QR, dan RFID, serta menggabungkan ketiga teknologi ini ke dalam Ekosistem Logistik Nasional (NLE), rantai pasokan logistik global dapat dikembangkan melalui sistem track and trace nasional. Sistem ini juga dapat meningkatkan efisiensi, transparansi, akuntabilitas, dan kualitas secara keseluruhan dalam infrastruktur logistik Indonesia. Tujuan ini dapat tercapai dengan membangun kolaborasi yang erat antara pemerintah dan sektor swasta, meningkatkan kemungkinan investasi dalam teknologi canggih, mengembangkan cetak biru untuk sistem track and trace nasional, serta menciptakan regulasi yang kuat untuk prosedur implementasinya.

Indonesia's logistics sector faces significant challenges due to fragmentation and poor integration among the logistics services provided by various government agencies. The National Track & Trace Logistics System is vital to the National Logistic Ecosystem, as it enhances distribution efficiency, advances digitalization, and promotes collaboration between the public and private sectors. The purpose of this study is to identify and explore the potential of integrating the National Track & Trace system with multiple digital technologies, creating a cohesive and collaborative platform for enhanced operational efficiency. The study used literature review in qualitative research, with a secondary data collection method. The finding shows that by integrating API, QR codes, and RFID technologies, and incorporating these three technologies into the NLE, the global logistics supply chain can be developed through a national track and trace system. The system also can enhance efficiency, transparency, accountability, and overall quality in Indonesia's logistics infrastructure. The goal can be achieved by building close collaboration between the government and the private sector, enhancing the possibility for investment in advanced technology, developing the blueprint for the national track and trace system, and creating strong regulations for the implementation procedure.

1. INTRODUCTION

Indonesia, as a vast archipelagic country with abundant natural resources, requires a robust logistics system to support economic growth.

The government has implemented several policies, including the National Medium-Term Development Plan (RPJMN) and various Presidential Regulations, to strengthen the national logistics system. One of the initiatives to strengthening the logistics system is the development of the National Logistics Ecosystem (NLE). The National Logistics Ecosystem (NLE) is a logistics ecosystem that streamlines the flow of goods and international documents from the arrival of the carrier to the delivery of goods to the warehouse. Presidential Instruction Number 5 of 2020 on the Organization of the National Logistics Ecosystem aims to improve national logistics performance, enhance the investment climate, and increase the competitiveness of the national economy.

Indonesia's logistics sector suffers from fragmentation, with poor integration among logistics services provided by various government agencies. This lack of cohesion, combined with outdated technology, leads to inefficiencies, increased costs, and a decline in the country's ranking on the Logistics Performance Index (LPI). Based on the World Bank's release of the LPI, Indonesia's ranking dropped 17 positions from 2018 to 2023, placing it sixth compared to other ASEAN countries (Supply Chain Indonesia, 2023).

The National Track & Trace Logistics System plays a crucial role within the National Logistic Ecosystem. The overarching goal is to create a unified and transparent logistics system that supports economic growth and investment, both domestically and internationally. Therefore, there are several substance benefits from track and trace in logistics, such as trust reinforcement, cost reduction, superior customer service, improved inventory management, better security, identification of bottlenecks in the supply chain, and real-time information about the delivery status (PackageX, 2022).

It becomes important to establishing a National Track and Trace system within the NLE. This system aims to enhance transparency and operational efficiency by providing real-time data and better integrating logistics processes across sectors. By improving coordination and access to information, the system is expected to reduce costs, speed up deliveries, and boost Indonesia's global competitiveness. Customs socializes the regulations related to the unloading and storage of imported goods as stipulated in the Ministry of Finance Regulation (PMK) Number 108/PMK.04/2020, and the regulations related to customs areas and temporary storage facilities as outlined in the Ministry of Finance Regulation Number 109/PMK.04/2020, to support the NLE in Indonesia.

The study aims to identify and explore the potential of integrating the National Track & Trace

system with multiple digital technologies, creating a cohesive and collaborative platform for enhanced operational efficiency. The technology can enhance the logistics quality system by connecting domestic and international distribution chains, including both public and private companies. The collaboration is not only about making it easier to connect each institution but also about creating a unified logistics ecosystem that brings together all stakeholders.

Based on the condition researcher decided to form three research questions, as following:

- a. What is a key barrier to creating a unified logistics ecosystem in Indonesia?
- b. How to create digital integration for the track and trace system and enhance the connection between each sector?
- c. How can the logistics integration system be successfully implemented?

This research significantly contributes to the logistics sector and policymakers by offering a comprehensive framework for integrating advanced digital technologies into Indonesia's National Track & Trace system. By emphasizing the importance of aligning logistics policies with operational realities and supporting technological advancements, the research offers actionable recommendations to enhance the effectiveness of the NLE system and drive long-term improvements in Indonesia's logistics infrastructure.

2. LITERATURE REVIEW AND HYPOTHESIS

2.1. Theoretical Framework

Universal real-time track and trace capabilities will empower digital ecosystems, such as digital supply chains, to thrive by addressing existing logistics inefficiencies (United Nations Economic Commission for Europe, 2023). Russell and Taylor (2011) said a supply chain includes all activities involved in the movement and transformation of goods and services from the raw materials stage to the end user (customer), along with the related information flows. Moreover, they define that supply chain management focuses on integrating and managing the flow of goods, services, and information, while also requiring close collaboration, cooperation, and communication among members to be effective (Russell and Taylor, 2011).

Shukla (2011) indicated that Supply Chain Management involves overseeing the flow of materials, money, personnel, and information both within and across the supply chain to enhance customer satisfaction and gain a competitive advantage. A supply chain can be described as a coordinated process involving multiple business entities—such as suppliers, manufacturers, distributors, and retailers—working together to: (1) source raw materials, (2) transform those materials

into finished products, and (3) deliver the final products to retailers (Beamon, 1998). The goal of supply chain management is to align customer demands with the flow of materials from suppliers, aiming to strike a balance between typically competing objectives: providing high customer service, minimizing inventory investment, and reducing unit costs (Stevens, 1989).

The Supply Chain Process can be seen in Appendix I.

The Council of Logistics Management (CLM) defines logistics as the segment of the supply chain process responsible for planning, implementing, and controlling the efficient and effective flow and storage of goods, services, and related information from the point of origin to the point of consumption, all aimed at meeting customer requirements (clm1, 2000, as cited in Larson, 2004). Global supply chains need integration and optimization, and while globalization has primarily driven profit growth through rapid revenue increases, smarter supply chains will also improve efficiency by enhancing visibility, allowing companies to identify and eliminate global delivery bottlenecks and quality issues (Butner, 2010). Power (2005), explained that the successful supply chain integration depends on effective implementation, and a well-informed strategy.

2.2. Tracking and Tracing System

The primary function of a track-and-trace system is to provide end-to-end transparency throughout the logistics chain, enabling customers, business partners, and the logistics company to monitor the exact production or delivery status at any given moment (Oliveira et al., 2013). Track-and-trace can be divided into forward tracking, which identifies the location of products along the supply chain, and backward tracing, which detects defective or lost items within the logistics network (Främling and Nyman, 2009, as cited in Goll & Nils-Ole, 2020). According to Goll & Nils-Ole (2020) track-and-trace technologies are essential for improving supply chain visibility.

The complexity of modern supply chain management and logistics has heightened the need for real-time visibility and continuous monitoring, necessitating goods-centric tracking and tracing to enhance visibility and control across various logistics operations (PackageX, 2022). United Nations Economic Commission for Europe (2023) discusses about tracking, which involves monitoring and recording the real-time location and status of traded goods, and tracing, which entails documenting the entire transport history of goods from the original consignor to the final consignee, across all transport modes and events. Furthermore, Tracking granularity mainly concentrates on the transport vehicles or equipment used as trackable assets, where traded goods are secured to ensure efficiency and protection from damage.

According to PackageX (2022) track and trace are essential elements of the supply chain, enabling logistics providers and companies to identify the location and status of goods. Moreover, "Track" involves monitoring the path created by a shipment's movement, while "Trace" extends to tracking not only the movement but also details like the package's temperature. In essence, track and trace is a method for recording the journey of parcels during transportation. Goods can be lost during handovers between systems due to inadequate communication capabilities between different systems (United Nations Economic Commission for Europe, 2023).

2.3. Application Programming Interfaces (API)

Application Programming Interfaces (API) are software tools that facilitate communication between different applications over the Internet. By standardizing data exchange between various platforms, APIs enable this interaction. They offer functionalities that are independent of specific implementations or definitions, allowing developers to create programs without needing to adjust their requirements (Urakar & Vishalakshi, 2022).

There are several types of API based on the protocol and the method, such as, (1) Simple Object Access Protocol (SOAP), initially developed by Microsoft and released as XML-RPC in 1998, is a protocol designed for web services, and it incorporates both web service (WS) security and secure socket layer (SSL) to prevent unauthorized access to the system (Qazi, 2023); (2) Remote Procedure Call (RPC), primarily used in client-server applications that allows one process to request a service from another process that may be on a different computer, within a different virtual address space, or across a network (Unkara & Vishalakshi, 2022); and (3) Representational State Transfer (REST) type, which has seen developers transitioning from SOAP and RPC to this approach. The REST architecture, introduced by Thomas Fielding in 2000, is based on principles that support the World Wide Web (www) (Neunman et.al., 2021).

The WebSocket Protocol allows for two-way communication between a client executing untrusted code in a controlled environment and a remote host that has consented to receive communications from that code (Fette & Melnikov, 2011).

2.4. QR Code

QR codes were developed in 1994 by Denso Wave Incorporated, a subsidiary of Toyota, primarily for managing car part inventories in manufacturing facilities. A QR code is a type of matrix barcode, also known as a two-dimensional code, that stores data and is designed to be scanned by smartphones (Tiwari, 2016). Moreover, Tiwari (2016), said that the term "QR" stands for "Quick Response," highlighting its ability to be quickly decoded at high speed. The key advantage of QR codes over traditional barcodes is their capacity to encode significantly larger amounts

of data. Additionally, QR codes feature a structured appending capability, allowing a single QR code symbol to consist of up to 16 smaller symbols, each containing unique information. This feature enhances data density and allows QR codes to be printed in a more compact form (Chang, 2014).

Funke (2024) explained two types of QRcode based on their tracking ability: Dynamic QR codes and Static QR codes. Dynamic QR Codes offer the ability to track user interactions, providing data such as scan locations, the number of scans, timestamps, and the operating systems of devices used. It is also allowed for differentiation between unique and repeat scans by the same user. Additionally, Dynamic QR Codes can be edited at any time, which is useful for correcting errors in the linked content or addressing issues with QR Code scanning. In contrast, Static QR Codes are both uneditable and untrackable. This type of QR Code is typically used for Plain Text, Email, or SMS QR Codes and is more suited for personal applications where tracking capabilities are not required (Funke, 2024).

2.5. RFID

Chetounane (2015) in his research explained that RFID (Radio Frequency Identification) is a wireless technology that captures data associated with different identification attributes—such as serial numbers, location, color, and purchase date—of items equipped with RFID tags. It operates through the exchange of electromagnetic waves between RFID tags and readers. As an Automatic Identification and Data Capture (Auto-ID) technology, RFID provides more detailed labeling than barcodes and earlier Auto-ID methods (Chetouane, 2015). Furthermore, unlike the barcode system, RFID can identify objects from a distance without needing a direct line of sight. RFID tags provide a broader range of unique IDs compared to barcodes and can include extra information such as manufacturer, product type, and environmental factors like temperature (Want, 2006).

One of the implementations of RFID as a tool for tracking and tracing is the e-seal container. According to Zhang et al. (2009), cargo seals are more prevalent in international trade than in domestic shipments, underscoring the enduring importance of Customs duties and cross-border smuggling. Moreover, Zhang et al. (2009) argue that RFID is often seen as a key technology for the future of logistics because it enables companies to monitor their goods at every stage of the supply chain. As such, RFID technology represents a significant advancement in enhancing supply chain visibility and efficiency.

3. RESEARCH METHODOLOGY

The research seeks to analyze the potential for integrating the National Track & Trace system with various digital technologies and creating a unified platform to enhance operational efficiency. This research method used literature review in qualitative research. Qualitative methods offer an opportunity to enhance knowledge in the professional state, still

valid for several business fields, and it encourages us to use our variation of skills, such as communication, interpretation, and analysis (Yates, 1993). A literature review can answer research questions by synthesizing insights and perspectives from a wide range of empirical studies (Snyder, 2019).

The data collection used a secondary data collection method, which means the data collected from published sources were originally gathered by someone else for a different purpose but can also be utilized for other research objectives (Taherdoost, 2021). Moreover, the data for this research was collected from books, journals, research articles, general websites, government official websites, records, and regulations, also several internet articles.

4. RESULTS AND FINDINGS

The absence of a national tracking and tracing system contributes to fragmented logistics operations in Indonesia, where disparate systems operate independently across government and private sectors. This lack of integration often results in inefficiencies, delays, and a lack of real-time visibility in the movement of goods. Cartenz Technology Indonesia (2024) reported that in developing the NLE, significant challenges arise due to limited active participation from private logistics service providers. Key issues include a lack of interest from the private sector, high operational costs influenced by various logistical and regulatory factors, and concerns over the technical functionality of the NLE platform, which is expected to face hurdles in 2024.

4.1. Integrating Tracking and Tracing Systems Across Private and Government Entities

Currently, various organizations in Indonesia operate independent tracking and tracing systems. For instance, the CEISA system, managed by Indonesia Customs, serves customs processes within a single portal system, including tracking the status of shipments (Indonesia Customs, 2023). Pelindo has E-Tracking that is used to trace port services, including vessel tracking and container tracking, online (Herlinda, 2017). Ministry of Transportation of Republik Indonesia also has their tracking system for goods and livestock animal (Directorate General of Sea and Transportation, n.d.). Meanwhile, in the private sector, e-commerce platforms like Shopee have their tracking systems for Shopee Express and collaborate with shipping companies such as JNE, TIKI, and J&T to provide tracking systems for customers (Shopee, 2022). Although these systems function effectively within their respective domains, their lack of integration creates fragmented data and inefficiencies. The fragmentation of these systems highlights the need for unified tracking and tracing on a national scale to streamline data and enhance coordination across Indonesia's logistics network.

Power (2005), said the three key components of an integrated supply chain model are: information systems (which manage information and financial flows), inventory management (which oversees the flow of products and materials), and supply chain relationships (which focus on managing interactions between trading partners). A unified tracking and tracing system on a national scale is crucial for addressing the issues of fragmented logistics operations in Indonesia. Integrating disparate systems can be effectively achieved by optimizing the NLE, which is designed to integrate government and private sector logistics systems. By consolidating data from various independent systems—such as Customs, Pelindo, Ministry of Transportation also the private sector systems like those used by e-commerce platforms such as Shopee, and the logistics management systems of companies like JNE and TIKI—into a single cohesive network, the NLE facilitates real-time data sharing and coordination among logistics stakeholders.

Collaboration through API Track & Trace can be achieved by establishing close cooperation with each entity's IT systems. The NLE portal can pull track & trace data from each entity in real-time, provided that a unique code for each logistics service is agreed upon in advance. By utilizing the NLE and implementing this collaborative approach, Indonesia can optimize its logistics performance, meet the objectives of the NLE, and enhance its LPI on a global scale.

4.2. Leveraging REST APIs for Unified Dashboards: Enhancing Real-Time Data Integration Across Multiple Systems

It is not easy to build a national track and trace system, a significant challenge arises because each institution—whether government or private—has already built its system for tracking and tracing, resulting in a variety of different systems that do not inherently communicate with one another. To overcome the issue, this study is proposed to use API. Through APIs, data from various tracking systems—such as CEISA for customs, Pelindo, and others government tracking platforms, also systems used by private companies like Shopee and JNE—can be consolidated into a single national portal. This consolidation makes it possible to monitor and manage logistics operations more effectively, aligning with the NLE's goals.

The concept of API and its various types were explored, we discuss that REST emerges as the most suitable choice to use in this integration project. Urankar and Vishalakshi (2020) argue REST is a flexible, stateless architectural style that supports various data formats like JSON and plain text, making it highly compatible with web browsers. REST can utilize transport-level security through SSL with HTTPS (Urankar & Vishalakshi, 2020). Aply (2024) explored that REST is more suitable than WebSockets, for the service integration and the use of

API. For most use cases, REST's ability to integrate disparate systems without extensive reconfiguration or rebuilding makes it the preferred option, particularly as businesses increasingly prioritize speed and efficiency in their digital operations (Jacobson, Brail, & Woods, 2011).

Please see Appendix 2 Table 1 for REST API and WebSockets Comparison.

Before diving into the specifics of preparing for the integration of diverse systems using REST APIs, it is essential to create the steps that ensure a successful and seamless implementation. We propose steps to prepare for using REST APIs to integrate diverse:

a. Creating API guidelines:

As we propose the NLE as the main system for the national track and trace network, we recommend that NLE coordinate with all parties involved in the integration to address technical needs, align infrastructures, set consistent standards, identify potential issues, and create comprehensive documentation.

b. Mapping the data:

NLE should identify data exchange requirements, analyze data structures, and develop detailed data mapping documents. Implement and test the mapping to ensure accuracy, address any discrepancies, and provide clear documentation. Continuous monitoring and maintenance are essential for successful integration.

c. Ensuring authentication and security:

Cartenz Technology Indonesia (2024) identifies data security concerns as a key barrier for stakeholders joining NLE. To address this, NLE should implement strong authentication methods and employ advanced encryption to secure data. Additionally, clear regulations on data security and sharing protocols are essential to build trust and encourage broader stakeholder participation.

d. Developing integration Logic:

NLE should create endpoints for data exchange, ensure data validation, and implement error handling and retry mechanisms to manage issues like failed requests.

e. Conducting testing and validation

NLE should perform thorough testing to verify integration accuracy, data consistency, and overall system performance. We suggest initiating a pilot with select stakeholders to allow for real-world evaluation, enabling NLE to fine-tune processes, address any challenges, and ensure smooth and reliable integration across all connected systems.

4.3. Overcoming Integration Challenges: Strategies and Solutions for Unified Logistics Systems

4.3.1. Data Compatible

In Indonesia, each entity operates its own tracking and tracing system, resulting in diverse data formats and standards that pose a significant data compatibility challenge. This diversity complicates the

development of robust integration logic required to manage complex API interactions and resolve operational conflicts. To mitigate these issues, establishing clear API guidelines and implementing comprehensive data mapping, as previously highlighted, are essential. These steps would provide a standardized framework to facilitate seamless integration across platforms, ensuring consistent and efficient data flow throughout the logistics ecosystem.

4.3.2. Addressing Authentication and Security

Considering the importance of authentication and security in the integration of diverse systems, it is crucial to understand that recent advancements in the digital space have made APIs prominent targets for threats. Although APIs are key to development and system integration, their standardized protocols and architectures can unintentionally make them easier targets for attackers. Common issues like broken user authentication, and insecure data transmission have been exploited in several recent security breaches (Gupta et al., 2024).

One effective solution that can be considered is to implement Single Sign-On (SSO). Pandey and Nisha (2021) explained SSO is an authentication method that uses a centralized session to allow a legitimate user to access multiple service providers with a single set of credentials, providing seamless and secure authentication across various platforms. In addition, Frontegg (2024) argues that SSO allows users to securely access multiple applications with a single set of credentials, enhancing security and minimizing risks associated with weak, repeated, or lost passwords. Furthermore, it is crucial to establish a dedicated unit within the NLE and enforce robust regulations to serve as a foundation for integration. This approach aligns with the recommendations by Cartenz Technology Indonesia (2024), which highlight the need for strong governance to address security concerns that deter stakeholders from joining the NLE.

4.3.3. Ensuring Scalability, Performance, and Reliability

Scalability and performance are crucial factors when integrating systems that manage large volumes of data and high transaction rates. System downtime and reliability are also critical for sustaining continuous operation. Pargaonkar (2023) mentioned that performance testing is essential for verifying the reliability, scalability, and responsiveness of software applications in today's rapidly evolving technological landscape. Conducting pilot tests can help identify potential issues and develop appropriate solutions. Additionally, implementing redundancy and regular data backups is critical to minimize outage risks. According to Flickerini (2024), these measures ensure that critical assets and services remain operational during unexpected outages by preserving data

integrity through failover systems and safeguarding against unforeseen events. Cloud backups can further enhance protection by storing data on remote servers, providing scalable solutions and rapid remote access (Flickerini, 2024).

4.4. Advancing Indonesia's National Tracking and Tracing System: Next Steps for Enhanced Logistics Integration

Once all Track & Trace APIs have been successfully integrated and coordinated within the NLE portal, the next logical step is to consider developing a national tracking and tracing system that could be utilized collectively by all logistics entities and cargo owners. The implementation of such a unified national system is anticipated to enhance the reliability and timeliness of logistics processes, addressing critical elements necessary for the efficiency of national logistics operations. However, this approach should be carefully evaluated by policymakers. The primary focus should first be on ensuring smooth integration of existing systems. Subsequently, policymakers can assess whether to implement a national track and trace system or maintain the current systems while relying on API integration. If the goal is to achieve maximum standardization and real-time coordination across the logistics ecosystem, a national tracking and tracing system could be advantageous. However, if the current API-based integration is effective and institutions prefer the flexibility of their systems, it might be more practical to continue enhancing the existing API framework without introducing a national tracking and tracing system.

In this section we are going to propose concepts to create an advancing national tracking and tracing system.

4.4.1. National QR Code Logistic Platform for Track and Trace System

The evolving QR Code technology can be leveraged by the NLE Track & Trace system to integrate and collaborate with various logistics systems. The QR Code issued by NLE could become the standardized national logistic QR Code, enabling seamless connectivity with the systems of individual logistics entities. Implementing this National QR Code requires standardization and technological capabilities across all logistics entities. As the national logistics system coordinator, NLE must maintain a robust IT infrastructure to store and manage all QR Code movement data from these entities in the NLE portal, allowing real-time usage. Every movement of goods between points must be tagged with this QR Code, ensuring it is read by the system within the NLE portal. All logistics entities and manufacturers must generate National QR Codes on the NLE portal and tag every shipment using smartphones or QR Code readers. This process will ensure that data is collected in the NLE portal and can be accessed collectively.

Once implemented nationally, this system should be expanded regionally to ASEAN and Asia, and eventually on a global scale. This expansion requires cross-border collaboration among NLE portals to ensure mutual benefits, enabling seamless tracking of goods and vessels. Challenges encountered during logistics processes should be visible in each country's track and trace system. The advancement of QR Code technology in the payment sector by Indonesia's national banks, in collaboration with Thailand, Singapore, Malaysia, and the Philippines, serves as a strong benchmark for developing cross-border QR Code logistics systems. According to ASEAN (2023), these five countries have been conducting trials since January 2023.

However, there are significant challenges to implementing such a system. One major challenge is the need for standardization. Each logistics entity currently operates with its own set of standards and technologies, which could make it difficult to adopt a uniform QR Code system. To overcome this, the NLE must establish clear guidelines and standards for QR Code usage, ensuring that all entities adhere to the same protocols. Another challenge is the varying levels of technological capability among logistics entities. Smaller companies may lack the resources to implement advanced tracking technologies or integrate them into their existing systems. The NLE can address this by investing in robust IT infrastructure and offering training initiatives to help all entities upgrade their systems to support the national QR Code standard.

4.4.2. RFID Technology in National Track and Trace System

In contrast to QR codes, which are more suitable for tracking individual packages or small-scale shipments, RFID technology offers a more robust solution for monitoring large containers over long distances. While QR codes require manual interaction for each scan, RFID systems provide automated data collection, reducing the likelihood of human error and increasing the accuracy of tracking data (Certags, 2022).

In the logistics industry, RFID technology has been widely adopted in e-seal to enhance the tracking and monitoring of container movements. For instance, Indonesia Customs (2023) implemented e-Seals to monitor and secure goods transported through bonded logistics centers (PLB). Adiyuna et al. (2024) found that Cikarang Dry Port also implemented e-Seals. Similarly, Indonesia Customs in Tanjung Priok uses e-Seals to monitor container movements (Indonesia Customs, 2016). The e-Seal technology is embedded in containers, allowing logistics companies to monitor container movements more efficiently and ensuring that goods remain secure throughout the supply chain.

The use of e-Seals by national logistics companies is becoming increasingly critical for enhancing the monitoring and movement of goods. To further improve the tracking of container movements by both

international and national shipping companies, RFID technology is essential. Each container should be equipped with an e-Tag that can be read by all logistics entities it passes through. If all containers are outfitted with e-Tags and this technology is integrated into each country's NLE portals, it will greatly simplify tracking for both container owners and cargo owners. A global e-Tag embedded in containers, readable by RFID machines across logistics entities, would provide better visibility throughout the supply chain. Therefore, there is a need for global e-Tag or e-Seal providers whose technology is compatible with all logistics entities. Reaching a global agreement on the use of RFID for containers is also crucial. Instead of each logistics entity deploying its own RFID technology, it would be more efficient to adopt a unified Global RFID Technology developed by leading information technology companies, making it broadly applicable.

However, implementing a global RFID system requires coordination among international logistics entities and the standardization of RFID technology across borders. This initiative would likely involve collaboration with leading IT companies to develop and maintain a globally recognized RFID system that can be universally adopted. It is essential to establish global agreements on the use of standardized RFID technology that can be universally adopted by all logistics entities to ensure compatibility and interoperability across different systems, making it easier to integrate RFID technology into national logistics ecosystems like Indonesia's NLE. Leveraging the expertise of leading information technology companies to develop and implement Global RFID Technology could help reduce costs and ensure that the system is accessible to all logistics providers, regardless of their size. If standardized e-Tags or e-Seals were adopted nationwide, regionally, or globally, the Track & Trace system within the NLE could become more robust and capable, providing a comprehensive solution for monitoring logistics operations across the entire supply chain.

4.5. Beneficial of Creating a National Track and Trace System

4.5.1. Enhancing Operational Efficiency and Coordination

A National Track and Trace System can significantly improve logistics efficiency and coordination by unifying the tracking of goods across different platforms. In Indonesia, logistics often involve fragmented systems among customs, port authorities, and private companies, leading to delays, miscommunication, and higher costs. A unified system would provide real-time access to information for all stakeholders—government agencies, logistics providers, and cargo owners—streamlining shipment tracking, reducing errors, and enabling faster response times.

4.5.2. Ensuring Transparency and Accountability

Implementing a National Track and Trace System enhances transparency by recording every movement of goods, making it easier to detect discrepancies and prevent illegal activities such as smuggling, illegal imports, and fictitious exports. A unified tracking system would provide customs authorities with the tools needed to identify suspicious activities, such as underreported imports or exports that do not match the actual flow of goods. Additionally, a transparent system builds trust among businesses, customers, and regulators, contributing to a more accountable logistics environment and potentially reducing the costs and time associated with audits and compliance checks.

4.5.3. Integrating Data for Better Analytics

Centralizing data from various logistics entities into a unified system enables comprehensive analysis, identifying bottlenecks, optimizing routes, and enhancing supply chain performance. This integration also allows customs officials to analyze patterns that could indicate illegal imports or fictitious exports, enabling quicker identification and intervention. For the industry, integrated data provides valuable insights into logistics trends, enabling companies to make data-driven decisions to improve efficiency, optimize inventory management, and reduce transit times.

4.5.4. Improving Reliability and Timeliness in Logistics

Improved reliability and timeliness mean enhanced customer satisfaction and loyalty, as businesses can provide more accurate delivery timelines and reduce disruptions in their supply chains. For customs oversight, reliable and timely data helps in monitoring compliance and preventing fraudulent practices such as the misdeclaration of goods or fictitious transactions.

5. CONCLUSIONS

5.1. Conclusion

The unification method can create a logistics supply chain that has interconnection to each other. The findings of this research reveal that there is a lack of integration among logistics services and government institutions in Indonesia that hampers both domestic and international distribution chains, including public and private entities. A national-level unified tracking and tracing system is essential for tackling the challenges posed by fragmented logistics operations in Indonesia. This can be effectively accomplished by enhancing the NLE, which is intended to integrate logistics systems from both the government and the private sector.

To address the digital integration, API can play a pivotal role by enabling seamless communication and real-time data exchange between various logistics platforms and governmental databases, which mitigates integration issues and enhances accuracy.

Furthermore, as integration progresses smoothly, considering the use of QR codes and RFID technologies could advance the system further. These technologies would enhance the system's capabilities, enabling more sophisticated tracking and facilitating international connectivity.

Building QR codes as the track and trace system offers a practical solution for real-time tracking and information access. QR code provides a straightforward way to capture and retrieve detailed shipment information, thereby improving transparency and traceability throughout the logistics network. Moreover, QR Code enhances the system's efficiency by allowing stakeholders to quickly verify and monitor the status of goods. Additionally, RFID technology further strengthens the integration by offering continuous, automated tracking of goods. RFID tags provide real-time updates on the location and status of shipments without the need for direct line-of-sight scanning. This continuous monitoring improves inventory management and reduces the risk of lost or misplaced items.

In the end, by integrating API, QR codes, and RFID technologies into the NLE, the global logistics supply chain can be developed through a national track and trace system. Furthermore, the system can enhance efficiency, transparency, and overall quality in Indonesia's logistics infrastructure. The government needs to build a more supportive ecosystem through reliable institutions with comprehensive and enforceable regulations and policies.

5.2. Recommendation

Based on this research, several recommendations are proposed to develop of a National Track and Trace System is essential. First, this requires close collaboration between the government and the private sector to create a unified system that integrates all logistics processes. Significant investment in advanced information technology infrastructure will be necessary to ensure seamless operation and integration. Additionally, optimizing the NLE is vital; the government should actively promote and facilitate the use of NLE by logistics and trade platforms through targeted incentives and strategic partnerships. Establishing a centralized logistics database is also crucial for improving data accuracy and accessibility.

Moreover, a comprehensive blueprint for the National Track and Trace System should be developed. incorporating API collaboration among logistics entities. To advance and integrate the system globally, the creation of a National QR Code Logistics Platform and the incorporation of RFID technology for containers are essential. Then, to ensure the success of the NLE, it is recommended to strengthen regulations and the oversight unit responsible for managing the NLE. This will enhance stakeholder confidence in joining the NLE by providing clear guidelines and robust support. Strengthening transparency policies is also critical; regulations should mandate that logistics

platforms share data with the National Track and Trace System, fostering a more transparent and accountable logistics environment.

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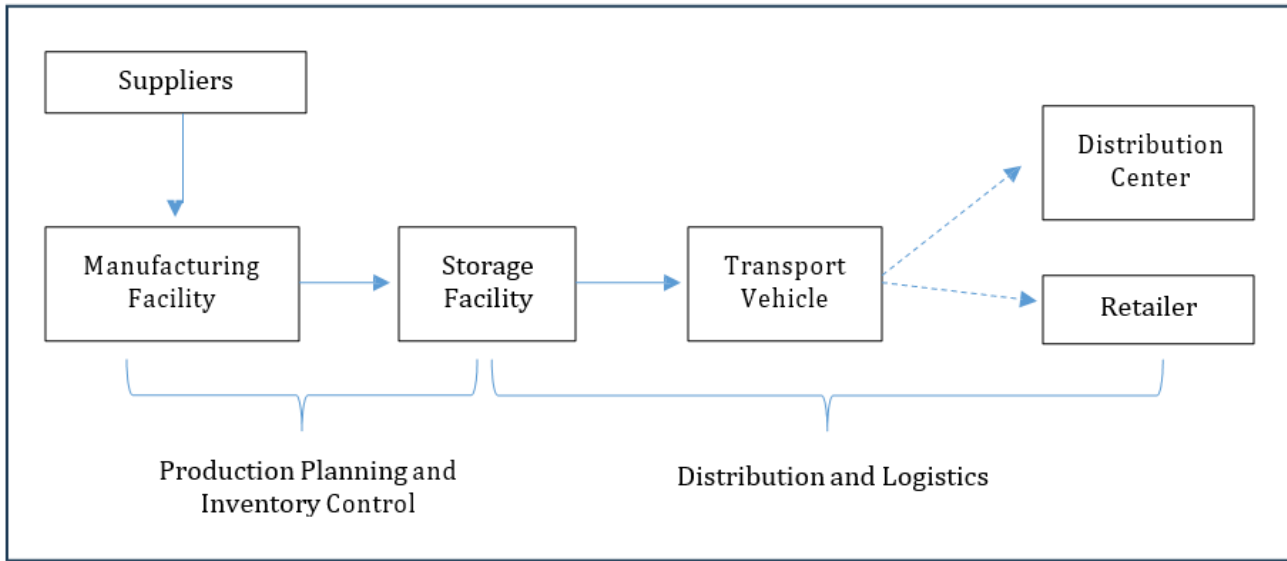
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APPENDIX I

Figure 1. The Supply Chain Process



(Source: Beamon, 1998)

APPENDIX II

Table 1. REST API and WebSockets Comparison

Aspects	REST API	WebSocket
Real-time	Stateless, request-response based	Stateful, persistent connection
Implementation	Not real-time, more suitable for request and response	Supports real-time communication
Data Format	Simple and easy to implement	More complex, requires connection management
Compatibility	Supports JSON, XML, plain text and other formats	Usually, JSON or plain text
Scalability	Highly compatible with many platforms	Requires support from both sides
Caching	Highly scalable and efficient for web	Suitable for real-time applications but more complex
Security	Supports caching to improve performance	Does not support caching
Network Overhead	Uses HTTPS for secure communication	Uses TLS/SSL, but more complex
Community Support	Low overhead, as communication is HTTP-based	Higher overhead due to persistent connections
Real-time	Wide community support and many tools	Growing community support

(Source: Author's own data)

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