

Web-based supply chain system design using blockchain



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Background: This research aims to design an agromaritime supply chain system as a development of blockchain technology in Industry 4.0.

Objectives: The study has three main objectives: (1) to analyse supply chain structures and processes, focusing on coordination, scheduling and resource control; (2) to explore the application of blockchain as an innovative solution in Industry 4.0; and (3) to design and evaluate a blockchain-based supply chain system that enhances transparency, traceability and data integrity through distributed ledger technology.

Method: Primary data were collected via observations and interviews with stakeholders involved in the supply chain obtaining information on production data, selling prices and orders for agromaritime products. Secondary data were collected from the previous studies in published journal articles, and the internet during research preparation.

Results: Using the prototyping method, the study showed that adopting blockchain in a supply chain significantly impacts companies, suppliers, farmers, and processors. It enables real-time, transparent transactions, reducing errors in buying and selling.

Conclusion: Blockchain benefits all supply chain actors, from to consumers by improving efficiency and providing a tracking system for events in the supply chain.

Contribution: This study contributes by developing a blockchain-based agromaritime supply chain web system to address trust issues such as corruption and misinformation, presenting data in real time.

Keywords: agromaritime; blockchain; data integrity; supply chain; transparency; website.

Introduction

According to Lubis and Rokhim (2021), as a tropical agricultural country and the largest archipelago in the world, where 75% of its territory is sea, Indonesia has enormous potential for agromaritime economic development, which until now has not been utilised optimally. The agromaritime sector is able to absorb around 30% – 60% of the workforce, contributes 20% – 60% of GDP, and accounts for 30% of the total export value. It also serves as a determinant of food security, energy, and pharmaceuticals, and creates extensive multiplier effects (World Bank 2016). During the period 2011–2019, the trend of the number of workers in the agriculture, forestry and fisheries sectors in Indonesia has decreased; but in 2020, it has increased significantly to 38.2 million people. The contribution of agromaritime sector to the total workforce in Indonesia is around 27% – 36% (Food and Agriculture Organization [FAO] 2021), which is the biggest compared to other sectors. More than 87% of the workforce in the agriculture, forestry and fisheries sectors are informal workers (BPS Indonesia Statistics 2019).

With the application of science, technological innovation, and effective management, the agromaritime sector can transform its comparative advantage into a competitive advantage (Adisetya 2022). This transformation will help address existing problems and challenges in the sector. It also has the potential to make a significant contribution to realising an advanced, just and prosperous Indonesia by 2045 (BPS Indonesia Statistics 2020).

To achieve optimal agromaritime development, several strategic steps are necessary. These include revitalising all existing business units in the agro sector – such as food crops, plantations, horticulture, livestock and forestry. The aim is to enhance productivity, increase efficiency and profitability, and improve competitiveness, inclusivity and sustainability.

In addition, it is necessary to develop agro sector businesses (food crops, plantations, horticulture, livestock and forestry) in new areas of land (extensification), based on land suitability and the carrying capacity of the regional environment. Moreover, agro sector business (food crops, plantations, horticulture, animal husbandry and forestry) has to be expanded with new species or varieties (diversification) in both existing and new agricultural lands. To achieve food sovereignty and security, food commodities currently produced nationally should not be imported. For commodities that are already produced domestically but require extensification and productivity increases, national production can be expanded over a period, for example, within three years. Imports may be allowed for up to three years, but must be controlled in a way that does not harm national producers. After that, imports should be stopped. However, for certain commodities (such as salmon and wheat), where technological interventions, extensification, and other efforts can ensure that national production is not significantly lower than national consumption, imports may continue without disrupting national producers.

Supply chain involves all activities or businesses including all parties who produce goods and provide services, starting from producers and/or suppliers of raw materials to final consumers (Lokollo 2012). Supply chain management involves the process of producing, shipping, storing, distributing and selling products to meet demand for these products, including all processes and activities involved in delivering these products to consumers (Usman, Ali & Ahmad 2021; Wuwung 2013). The supply chain management system in agro-industry since the 2000s is a centralised system.

In this study, the agromaritime supply chain is conceptualised as an integrated network that encompasses the production, processing, distribution and delivery of agricultural and marine-based commodities. This supply chain involves multiple actors – from smallholder producers and suppliers of raw materials to processors, distributors and end consumers – working within a coordinated system aimed at meeting the demands of the customers Rebula (2023).

According to Lokollo (2012), the supply chain includes all business activities involving parties who produce or process goods and services, spanning from raw material suppliers to final consumers. Wuwung (2013) further emphasises that supply chain management involves processes such as production, transportation, storage and sales, ensuring that products reach consumers effectively. In the agro-industry context, particularly since the early 2000s, supply chain management systems have largely been centralised, often leading to challenges in transparency and data sharing.

This study builds on these definitions by incorporating *blockchain technology* to propose a more *decentralised, transparent and traceable* agromaritime supply chain

model – better suited for the evolving demands of the industry in the digital era (Lutfiani 2020).

A centralised supply chain management system has weaknesses, including still having a centralised authority, which can lead to problems of corruption, system security issues and inappropriate information, which can make the supply chain system not to work as planned (Pillay 2021). Integrating supply chain management allows the company to explore sustainable alternatives in design, sales, promotion, and distribution plans, all aimed at meeting customer expectations (Rebula de Oliveira et al. 2022). Another weakness is that data are not presented in real-time and transparent and takes time to process and present. Incorporating blockchain technology in supply chain management systems helps overcome these problems (Dwi 2019).

Blockchain technology is a significant outcome of the advancements driven by the Fourth Industrial Revolution (Industry 4.0) (Situmorang 2021). It is defined as a distributed ledger that tracks every activity in the block chain, where each activity record is a validated activity (Bogart & Kerry 2015). Sustainable development is an increasingly important issue in the management of the supply chain (Rodrigues et al. 2023). Each inner blockchain contains data from all transactions within the system for a specific period of time and can generate a digital signature used to verify the validity of information related to both the next and previous blocks (Bruce 2013). Transactions that have been made will be stored in hash blocks. If the transaction has been verified by a consensus of all or a majority of members in the network, the transaction that has been stored in the block cannot be changed or deleted (Gozali et al. 2024). Hyperledger fabric is one of the frameworks to develop a system or application based on blockchain (Yusra Fadhillah 2022). Scherer (2017) states that Hyperledger fabric is faster and easier to develop, compared to Bitcoin and Ethereum and can ensure that data in the system can only be accessed by participants involved in the network, so that participants can see the details of the transactions made.

The methodology used in this research is prototyping method. This research utilises agromaritime web-based supply chain system design by using blockchain which can record transactions and information on the actors involved in the supply chain and enable traceability of the agromaritime supply chain on an ongoing basis (Tian 2016). Records are made real-time and transparent using user ID originating from the actors, ultimately fostering trust among the users. Using blockchain can provide benefits for all actors in the supply chain, from upstream to downstream (Zheng et al. 2017).

Methodology

The research design used in this study is the prototyping method. This research employs a web-based supply chain

system design as a proof of concept (POC) using blockchain technology. Blockchain can record transactions and information on actors involved in the supply chain, enabling real-time traceability and transparency through user IDs. This enhances trust among users and provides benefits for all supply chain actors, from upstream to downstream (Usman et al. 2021).

The data gathered in this study involved primary data and secondary data. Primary data were collected through nonparticipant direct observations and semi-structured interviews. The observation followed a structured protocol that included predefined checklists focusing on supply chain transactions, interactions of various actors involved in the supply chain and the use of digital tools across multiple nodes in the agromaritime supply chain (Bangare et al. 2016). Observations were documented in field notes and photographs, and the data were triangulated with interview responses to ensure data credibility.

Interviews were conducted with stakeholders directly involved in the agromaritime supply chain to gather detailed insights into production data, pricing structures and product distribution flows. The interviews employed a semi-structured format, guided by a validated interview protocol and were conducted both face-to-face and online via Zoom, depending on the availability and location of the respondents. A total of 15 participants were interviewed, including owners of micro, small, and medium enterprises (MSMEs), supply chain managers and local collectors. These individuals were selected purposively due to their direct involvement in the production and distribution of agromaritime products such as dried seaweed, coconut, shrimp and smoked fish. Data saturation was considered reached when no new themes or variations emerged after the 13th interview.

Scientific rigour was maintained through several strategies. Trustworthiness and credibility were ensured by triangulating interview findings with observational data and secondary sources. Transferability was ensured by providing detailed contextual descriptions of the research setting, while dependability was achieved through consistent use of data collection tools and peer debriefing. To minimise bias, the researchers employed reflexivity, member checking and ensured that questions were neutrally worded and uniformly applied across interviews.

Secondary data were obtained from peer-reviewed journals, government publications and reputable online databases during the research preparation phase. The focus was on agromaritime products produced by MSMEs and individual entrepreneurs (Bahauddin 2019). Key data included quantities of raw materials and the flow of products across the supply chain, from upstream producers to downstream consumers.

The data processing analysis was conducted using Design Analysis. Primary and secondary data were collected to create an agromaritime web-based supply chain design using blockchain. The prototyping method employed in this

study involved five stages: (1) communication, (2) quick planning, (3) modeling quick design, (4) prototype construction and deployment, and (5) delivery and feedback.

The data collected from observations and semi-structured interviews were first analysed using thematic analysis to identify recurring patterns and key themes relevant to the agromaritime supply chain. These themes informed the subsequent design analysis phase, which guided the development of a blockchain-based web system tailored to the operational needs and challenges identified in the field. The design analysis was implemented using a prototyping methodology with five stages: (1) communication, (2) quick planning, (3) quick design modeling, (4) prototype construction, and (5) deployment, delivery, and feedback.

Ethical considerations

This study received ethical approval from the Research Ethics Committee of Politeknik Pelayaran Surabaya on 31 January 2025 with ethical clearance number 09/TRANSLA/I/2025. All participants provided informed consent prior to data collection, and confidentiality was maintained throughout the research process.

Results and discussion

This section addresses the research objective: to design a blockchain-based supply chain system that enhances traceability, transparency, and trust among actors in the agromaritime sector. The findings presented here are derived from thematic analysis of both field observations and qualitative interviews with key stakeholders.

The analysis identified the key components and workflow of a technology-based supply chain traceability system for agromaritime products, focusing specifically on family planning commodities. The system involves six primary actors: factories (processing units or customers), companies (providers), coconut farmers, collectors (suppliers) and trucking expeditions (as both sender and receiver couriers). Each actor plays a distinct role in the transaction and logistics processes, forming an interconnected network where transparency and real-time data exchange are essential. These roles and relationships formed the basis for the system design and flow illustrated in the subsequent figures and use case models. Whereas customers can also see supply chain traceability as illustrated in Figure 1.

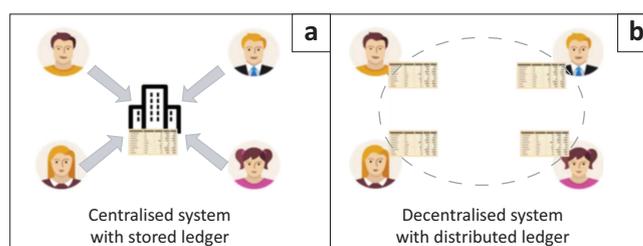
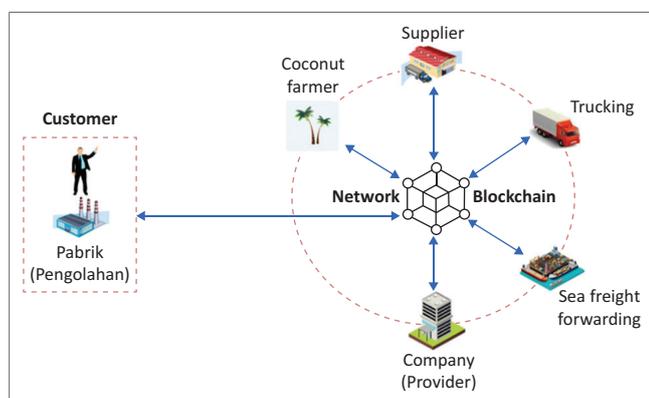


FIGURE 1: Network of supply chain system using blockchain technology: (a) Centralised system with stored ledger; (b) Decentralised system with distributed ledger.

The supply chain transaction system flow has three main functions in the blockchain system namely: making transactions, confirming transactions and viewing transactions. The flow of transactions between actors can branch, starting from a single transaction and resulting in five separate transactions. Although these five transactions are separate, they can be traced back to the same coconut farmers and suppliers (collectors) as the origin of the sold KB.

Based on the results of the interviews, an analysis of the business processes within the participating agromaritime company (provider) was conducted. As a result, the business processes modelled in this study focused on the flow of information and transactions related to the demand and distribution of agromaritime products. These include items such as coconuts, seaweed and other marine-agricultural commodities. The supply chain activity flow at the agromaritime provider company is illustrated in Figure 2.

As illustrated in Figure 2, suppliers (collectors) obtain agromaritime product supplies – such as coconuts – from multiple sources, including plantations owned by the company (providers) as well as community-managed gardens. Round crested coconut (KB) originating from community-owned gardens cannot be sent directly to the port but must go through supplier (collectors) to then carry out the sorting process in accordance with the company's quality standards. The workers in the sorting section perform quality checks related to size and grade, too young, too thick coir, buds open and/or leaking, broken, mouldy, among others. KB rejected by supplier (collectors) will be returned or processed into copra. Only those KB that are in accordance with company standards are counted. Furthermore, after the sorting process, the KB is sent to the port with delivery CY-CY, Door to Door, CY to Door or Door to CY using Expedition (Trucking) to put in the container (stuffing) or can be done with stuffing outside the port, according to the schedule determined by the Expeditionary Party (EMKL). After sealing and



KB, round crested coconut.

FIGURE 2: Flow of supply chain activities in the production and distribution of round crested coconut.

weighing, the container is sent to the destination port. Upon arrival at the next port, it is transported to the factory (processing) according to a predetermined schedule, taking into account the time limit for demurrage at the port. After arriving at the processing factory, weighing and handling are carried out and the sorting process is carried out again according to the factory quality standards (processing) so that those that are not suitable (with respect to size and grade, too young, too thick coir, buds open and/or leaking, broken, mouldy, etc.) can be identified by the quality control (QC) team.

The use case diagram in Figure 3 shows the interaction among six key actors – Customer, Admin, Owner, Shipper Courier, Recipient Courier and Farmer – within the agromaritime blockchain-based supply chain system. Each actor has specific functions, including registration, sign-in or sign-out, order management (purchase or sales order), inventory updates, data reporting and delivery tracking. This structure ensures transparency, traceability and real-time coordination throughout the supply chain process are essential for enhancing transparency and efficiency.

The involvement of multiple stakeholders at each stage, as details in Table 1, reflects the complexity and interconnectedness of agromaritime supply chains. This design aligns with the prior studies emphasising the benefits of distributed ledger technology in reducing transaction friction and enhancing traceability (Francisco & Swanson 2018; Saberi et al. 2019). Furthermore, the integration of dashboards, inventory control, and order tracking, illustrated through the system use cases in Table 2, providing stakeholders with data-driven decision-making tools. This is consistent with the findings of Casino, Kanakaris and Dasaklis (2019), who highlighted the importance of blockchain in improving supply chain visibility and efficiency.

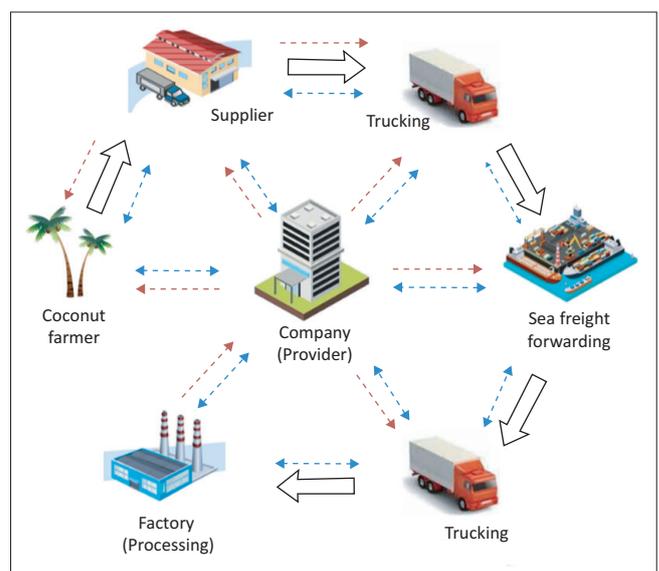


FIGURE 3: Use case diagram of the supply chain system.

TABLE 1: Identification of actors in the supply chain process.

Number	Actors	Description	Activities
1	Customer	Factory (Processing)	<ul style="list-style-type: none"> Register Sign-in Dashboard Catalogue Invoice Delivery order Sales order
2	Admin	Company (Provider)	<ul style="list-style-type: none"> Inventory Invoice Purchase order Sales order Delivery order Item data Master status
3	Owner	Company (Provider)	<ul style="list-style-type: none"> Purchase order Sales order
4	Shipper courier	Expedition (Sea freight forwarding and trucking)	<ul style="list-style-type: none"> Delivery order Master status Delivery order status
5	Recipient courier	Expedition (Sea freight forwarding and trucking)	<ul style="list-style-type: none"> Delivery order Master status Delivery order status
6	Farmer	Supplier	<ul style="list-style-type: none"> Update stock

Figure 4 illustrates the login page interface of the developed Supply Chain Management (SCM) application. The interface includes a user-friendly layout with input fields for username and password, allowing authorised users to securely access the blockchain-based system. The inclusion of a login feature is essential for ensuring user authentication, which is a core component of information security within blockchain applications.

This login system not only serves as a gateway to system functionality but also supports role-based access control, ensuring that each actor (e.g., farmers, couriers, customers and administrators) can interact with functions relevant to their roles in the supply chain, as described in Figure 3. The use of such a secure access mechanism is consistent with industry best practices, which recommend incorporating identity verification and access permissions in blockchain-enabled platforms to maintain data integrity and confidentiality (Mansour, Smith & Johnson 2020).

Conclusion

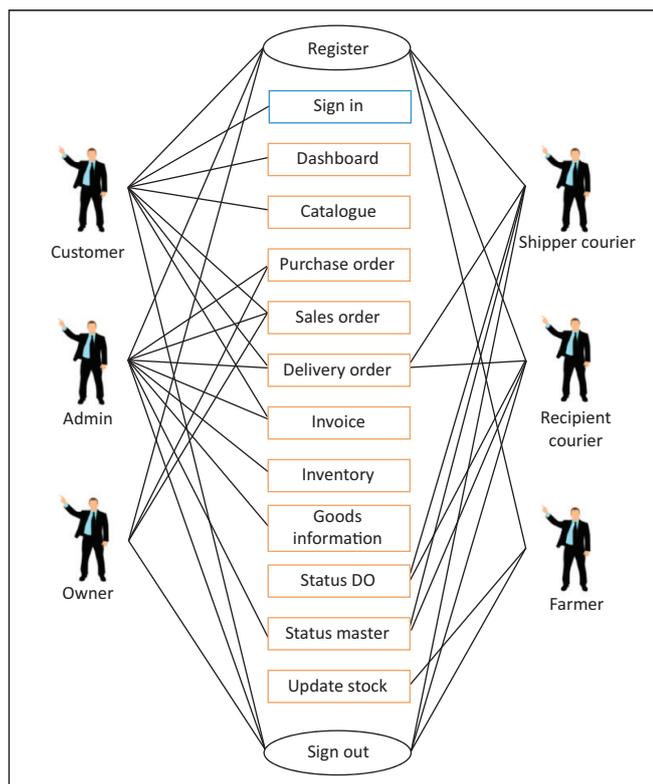
The result of this research is the development of a web-based supply chain application using blockchain, which can be accessed through an internet connection. The blockchain-based supply chain system is designed to have a positive impact on companies (providers), suppliers (collectors), farmers, and factories (processors acting as customers), enabling them to trace transactions and information transparently and in real time, thereby minimising errors in buying and selling activities.

TABLE 2: Use case identification for system interaction and user activities.

Number	Actors	Description
1	Register	<ul style="list-style-type: none"> Customer Admin Owner Sender courier Recipient courier Farmers carry out the registration process on the application
2	Sign in	<ul style="list-style-type: none"> Customer Admin Owner Sender courier Recipient courier Farmers can enter data in the main page by filling the name and password correctly
3	Dashboard	<ul style="list-style-type: none"> Customer Admin Owner Sender courier Recipient courier Farmers can enter data in the main page by filling the name and password correctly
4	Catalogue	<ul style="list-style-type: none"> List of information related to the products offered with a description of prices and product specifications
5	Purchase order	<ul style="list-style-type: none"> List of information including the quantity and quality, product price to be ordered by the customer, order date, delivery schedule, payment method, and other information related to the transaction.
6	Sales order	<ul style="list-style-type: none"> List of information related to the products offered with a description of prices and product specifications
7	Delivery order	<ul style="list-style-type: none"> List of product order transactions
8	Status delivery order	<ul style="list-style-type: none"> List of product order transactions
9	Invoice	<ul style="list-style-type: none"> A list of bills containing details of transactions made
10	Inventory	<ul style="list-style-type: none"> A list of bills containing details of transactions made
11	Item data	<ul style="list-style-type: none"> List of reports of goods that have been ordered
12	Status master	<ul style="list-style-type: none"> List of reports of goods that have been ordered
13	Update stock	<ul style="list-style-type: none"> List of product availability information in the form of product name, quantity and quality information and price
14	Sign out	<ul style="list-style-type: none"> Customer Admin Owner Sender courier Recipient courier Farmers can exit or close from the main account of the system

Incorporating blockchain technology into a supply chain system is very helpful for companies (providers) in buying and selling activities where transaction reports can be recorded quickly and effectively and make it easy for administration officers to access the information needed in processing buying and selling data.

Blockchain technology, designed to support the business flow of buying and selling round crested coconut (KB), is implemented using the Python programming language along with PostgreSQL, jQuery, and CSS Bootstrap 5. The system helps companies with secure data storage. When data is input into the blockchain system and the save button is clicked, the system automatically stores it in a decentralised



DO, delivery order.

FIGURE 4: Supply chain management application login page.

blockchain hash block. This ensures that the data is secure, tamper-resistant, and authentic—providing convenience in processing buying and selling transactions more quickly and accurately.

The developed agromaritime supply chain web-based system utilises blockchain technology to enhance the traceability and security of transactions, specifically in the context of buying and selling round jambul coconut. The system is implemented using Python as the main programming language, with PostgreSQL for database management, and a front-end interface built with jQuery and Bootstrap 5 for CSS styling (Sutedjo 2000).

The system operates as follows. First of all, users (e.g. suppliers, buyers or administrators) log in to the platform through a secure authentication portal (see Figure 4). Once logged in, users can input relevant transaction data such as purchase orders, delivery records and inventory updates. Upon clicking the 'Save' button, the data is automatically hashed and stored into a decentralised blockchain ledger.

Each transaction is converted into a cryptographic block, which is then linked with the previous block, forming a secure and immutable chain of records. This blockchain mechanism ensures that the data cannot be tampered with, offering data authenticity, transparency, and integrity across the supply chain. As a result, stakeholders benefit from a system that is faster, more accurate, and resistant to data manipulation, thus improving operational efficiency and

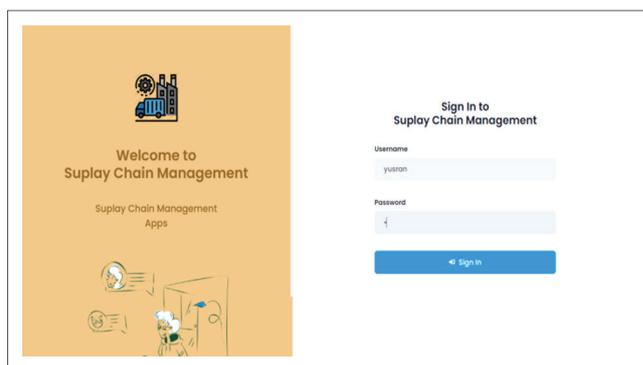


FIGURE 5: User interface of the supply chain management application showing the welcome screen and login page.

trustworthiness in the agromaritime product trade, as illustrated in Figure 5 (Untung Rahardja 2020).

This approach is especially crucial for supply chains involving multiple independent actors, as it minimises the risk of data manipulation and ensures real-time traceability of product flow from producers (e.g. farmers) to end consumers

In this system, there are still limitations and deficiencies and requires improvement to increase the benefits of this system which can be explored in future research (Pressman & Maxim 2015). System development can be done through mobile applications such as Android, iOS and others because mobile applications are much faster and more practical according to the needs of users in the supply chain system, so they can access applications anywhere through their gadgets (Meidhianto et al. 2021).

This system can be enhanced by integrating GPS (Global Positioning System) to track the location of drivers or ships from the expedition service, making the shipping tracking process easier and faster. The company should provide training on the use of this system to all the actors involved in the supply chain in order to improve the quality of existing human resources and make it easier for customers to process transactions.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

F.N. conceptualised the study and led the research at Polteknik Surabaya. M.R.B.J. contributed to the design and

implementation of the study. R.A.P. assisted with data analysis, manuscript writing and editing. All authors, F.N., M.R.B.J. and R.A.P., reviewed and approved the final manuscript.

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Data availability

The data supporting the findings of this study are available upon request from the corresponding author. There are no publicly available datasets associated with this study. All figures in the manuscript are based on the data analysed during the research.

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