THE ROLE OF ROBOTIC TECHNOLOGY AND RADIO FREQUENCY IDENTIFICATION (RFID) IN ENHANCING THE EFFECTIVENESS OF DIGITALIZATION AND AUTOMATION OF LOGISTICS SERVICES: A STUDY ON PT POS INDONESIA (PERSERO)

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Abstract. *Digital transformation in logistics is critical in the era of the Fourth Industrial Revolution, especially for state-owned enterprises like PT Pos Indonesia (Persero), which compete with startups and private logistics companies. This research shows that the implementation of robotic technology and Radio Frequency Identification (RFID) is not yet optimal. This shortcoming is caused by issues such as limited system integration, lack of human resource training, and the mismatch between technology features and field needs. The main objective of this research is to see how robotic and RFID technology help improve the digitalization and automation of PT Pos Indonesia's logistics services. This research uses a causal associative quantitative approach. Data were collected from 250 individuals directly involved in the use of robotic and RFID technology at PT Pos Indonesia. Partial Least Squares Structural Equation Modelling (PLS-SEM) was used to analyse the data using the SMARTPLS 4.0 application. The results show that RFID technology has a positive and significant impact on digitalization effectiveness (0.081, p-value 0.516) and service automation (0.706, p-value 0.000). Conversely, robotic technology has a positive and significant impact on digitalization effectiveness of 0.130, with a p-value of 0.231, but does not have a significant impact on service automation with p-values of 0.098 and 0.316. As a result, compared to robotic technology, RFID is more effective in supporting the digitalization and automation of logistics services. This study found that the integration of RFID technology is a crucial component in driving the digital transformation and automation of logistics services at PT Pos Indonesia (Persero).*

Keywords: *Automation of Logistics Services; Digitalization Effectiveness; Radio Frequency Identification (RFID); Robotic Technology*

1. INTRODUCTION

In the era of the Industrial Revolution 4.0, all business sectors must switch to digital. This includes the logistics industry. Digitalization and automation are essential to improve the accuracy, efficiency, and speed of logistics services. According to a McKinsey & Company report (2020), technologies such as Robotic Process Automation (RPA) and Radio Frequency Identification (RFID) can increase logistics productivity by up to 45% and reduce operational costs from 20% to 30%. These technologies can replace manual processes and reduce the rate of human error.

Fast and efficient logistics systems are increasingly needed as Southeast Asia's e-commerce volume is expected to reach US$95 billion by 2025 (Google, Temasek, & Bain & Company, 2023). This means that companies that provide logistics services must use advanced technology during the distribution process of goods. Countries such as Germany and Japan have even implemented warehouse robots and RFID systems to improve warehouse management efficiency and surveillance accuracy.

PT Pos Indonesia (Persero), one of Indonesia's oldest and largest logistics companies, faces a major challenge to remain competitive amid the dominance of private logistics companies and more agile digital startups such as JNE, J&T, SiCepat and Grab

Express. Robotic sorting systems and RFID-based surveillance in mail and package management are one of the transformation strategies carried out by this company.

However, the implementation of this technology is not fully optimal, according to media interviews and Pos Indonesia's internal reports (Katadata, 2023). Some of the issues faced include a lack of system integration, a lack of employee training, and a mismatch between field needs and the technology features being implemented. With this phenomenon, important questions arise about how effectively robotic and RFID technologies can improve the digitalization and automation of enterprise logistics services.

PT Pos Indonesia started its digital transformation in 2017 with the launch of the PosAja! and digitization of service points. The company began using robotic technology to sort mail and packages in 2023 and began integrating RFID to make the loading and unloading process of shipments easier for carriers. However, until 2024, the success of this technology is still questionable due to undeveloped customer satisfaction data and longer delivery times than private competitors (PT Pos Indonesia Performance Report, 2023).

The development and development of digitalization and automation of courier and logistics operations in the form of strengthening the existing system, operational infrastructure is aligned with the road map of information technology development in the Company and can be changed and adjusted to the development of business and operational needs of couriers and logistics in general and changes in the vision, mission, strategy and transformation of PT Pos Indonesia (Persero).

Robotic technology and Radio Frequency Identification (RFID) have been implemented at the Surabaya Post Processing Central office and the Jakarta Post Processing Office. The application of robotics technology and Radio Frequency Identification (RFID) is carried out in stages contained in the Company's Long-Term Plan and Budget Work Plan as well as the Company's Work Program in the Operations and Digital Services midwifery.

Although robotic and radio frequency identification (RFID) technologies play an important role in improving the effectiveness of digitalization and automation of logistics services, their optimal utilization relies heavily on reliable cloud computing infrastructure; however, challenges such as data security, network latency, and limited scalability are often major obstacles in the comprehensive integration of these technologies into digital-based logistics systems (Maniah, 2020, 2022)

Previous research has usually only addressed the digitalization of logistics as a whole, without paying attention to how robotic and RFID technology contributes to state-owned companies such as PT Pos Indonesia (Persero). For example, a study conducted by Wibowo & Pratama (2022) only discusses the function of digital monitoring in e-commerce shipments without considering the aspect of physical automation through robotic processing. Nugraha (2021) examines RFID in the manufacturing of supply chains, but not in the context of national logistics providers.

Therefore, this study offers novelty in the form of an integrative and specific analysis of how robotic technology and Radio Frequency Identification (RFID) combined improve the digitalization and automation of logistics services in SOEs, especially PT Pos Indonesia (Persero).

This research aims to provide a better understanding of how effective the use of robotic technology and Radio Frequency Identification (RFID) is in Pos Indonesia's logistics operations and offers a strategic solution based on empirical results to solve this problem. It is hoped that this research will help company policymakers in making changes, ranging from HR training to system design.

2. LITERATURE REVIEW

2.1 Introduction to Literature

Literature review plays an important role in establishing a conceptual framework for research by synthesizing existing knowledge and identifying gaps that require further

investigation. In the context of centralized procurement practices, particularly in the logistics sector and State-Owned Enterprises (SOEs), this review focuses on the definitions, concepts, and theoretical foundations that shape the effectiveness of digitalization and automation of logistics services Wang et al. (2019). The structure of this literature review will be structured into key themes, including the definition and combined role of robotics technology and Radio Frequency Identification (RFID) in improving the effectiveness of digitalization and automation of logistics services, and empirical studies highlighting the factors driving successful implementation in both the global and Indonesian contexts (Murphy & Eadie, 2019).

2.2 Definition and Concept of Robotic Technology

Robotics Technology is an independent variable that refers to the part of the industrial automation system used to increase productivity and work precision (Groover, 2015). The main concept is the use of robots to perform repetitive, heavy, or dangerous tasks, such as sorting, moving goods, and picking, with the goal of reducing human involvement and increasing speed and accuracy. This variable is measured through several indicators, namely the use of robots for sorting, labor efficiency, reliability of robotic systems, and robotic system integration capabilities. The measurement of these indicators will be used on an ordinal scale. In the context of PT Pos Indonesia (Persero), robotic technology is the digitization and automation of courier and logistics operations that is implemented to replace manual processes and conventional methods that have been used in postal processing operations, with the aim of increasing efficiency, accuracy and speed of service.

2.3 Definition and Concept of RFID Technology

Radio Frequency Identification (RFID) technology is also an independent variable defined as an automatic identification technology that works with radio frequency signals. Radio Frequency Identification (RFID) can improve the efficiency of tracking and logistics management by reducing manual input errors and providing real-time visibility in the distribution process of goods (Finkenzeller, 2010). The RFID concept allows for the identification of objects wirelessly via radio waves, facilitating the automatic tracking of goods without the need for a line of sight, which is very useful for inventory management, shipment tracking, and product authentication. The tools used to measure these variables are tracking accuracy, input/output process speed, RFID integration with logistics systems, and cost and efficiency of RFID use. The measurement scale used for these indicators is ordinal. PT Pos Indonesia (Persero) has begun to integrate Radio Frequency Identification (RFID) to simplify the loading and unloading process of shipments with the transportation party.

2.4 Definition and Concept of Digitalization Effectiveness

Effectiveness of Digitalization is the first dependent variable defined as the application of digital technology to redesign business processes to improve efficiency and quality of service (Meyer & Allen, 2019). The concept of digitalization effectiveness is measured by the extent to which the implementation of digital technology has succeeded in improving the operational and strategic performance of logistics companies, especially related to the speed of information processing and data accuracy. Indicators for these variables include the speed of information processing, system accessibility and integration, data accuracy and reliability, and ease of use of digital systems. The measurement of these indicators will be carried out using an ordinal scale. PT Pos Indonesia (Persero) has started a service point digitization program since 2017.

2.5 Definition and Concept of Service Automation Effectiveness

Service Automation Effectiveness is the second dependent variable that refers to the utilization of technology equipment and systems to speed up processes, reduce manual interventions, and improve the efficiency and accuracy of logistics services (Rushton,

Croucher & Baker, 2017). The concept of service automation effectiveness focuses on the direct impact of the use of automated technology on physical processes, such as the speed of handling goods, the reduction of operational costs associated with labor, and the lack of errors in processing. These variables are measured through indicators of goods processing speed, operational cost efficiency, reduction of manual labor, and the rate of processing errors. Just like any other variable, the measurement scale used is ordinal. Although PT Pos Indonesia (Persero) has adopted robotic technology for automation, the effectiveness of the implementation of this technology is still questionable, as can be seen from stagnant customer satisfaction data and delivery times that have not yet competed with private competitors (PT Pos Indonesia Performance Report, 2023). Customers or product users are the main target of the production activities of every product that has been produced by the company. The customer in this context is of course a loyal consumer who uses products or services for a long time. For customers to be loyal, customers must first be satisfied with the services provided by the Company (Rizki Alifnur Harmawan, Erna Mulyati, 2024).

The use of robotic technology and Radio Frequency Identification (RFID) is expected to improve the quality of operations, cost efficiency, and can raise the image of PT Pos Indonesia (Persero) in its implementation, so the use of robotic technology and Radio Frequency Identification (RFID) is considered the most appropriate choice as a reference in improving the performance of PT Pos Indonesia (Persero) continuously.

3. RESEARCH METHODS

To analyze this study, a causal associative quantitative method was used to see how robotic and RFID technology impacts how effective the digitization and automation of PT Pos Indonesia's (Persero) logistics services are. To collect data, questionnaires were distributed to 250 employees out of 250 employees of PT Pos Indonesia; they include logistics operations staff, warehouse managers, IT teams, and digital transformation divisions. To select respondents, a purposive sampling method was used. They must be actively involved in the digitization or automation process of logistics and have a minimum of one year of experience working with robotic or RFID technology. The stages of Methodological Research Implementation include:

3.1 Research Planning:

a. Formulating Problems and Objectives: Identify the problems to be investigated and formulate the objectives of the research clearly.
b. Preliminary Study/Literature Review: Gather information related to research issues through literature, references, and preliminary studies to understand the research context.
c. Determining Samples and Populations: Identifying the object or subject to be studied and determining the number and characteristics of the sample.

3.2 Data Collection:

a. This stage is the core of the research implementation where data is collected according to the design that has been made.
b. Data collection methods may include observation, interviews, questionnaires, documentation studies, or other appropriate methods.
c. Data can be obtained from primary sources (directly from the research object) or secondary sources (from existing documents or sources).

3.3 Data Analysis:

a. Once the data is collected, the next step is to process and analyze the data.
b. Data analysis is done to test hypotheses (if any), find patterns, relationships, or trends in the data.
c. Analysis method using the SMARTPLS 4.0 Application

3.4 Research Results and Discussion:

a. The final stage is to present and report the research findings in a systematic and logical manner.

b. Research reports typically include introductions, literature reviews, methodologies, research results, conclusions, and suggestions.

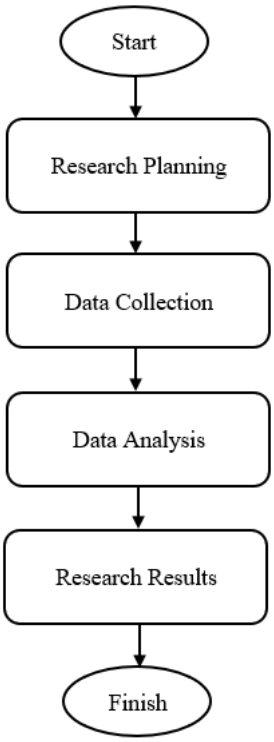

Figure 1. Stages of Research Implementation

4. RESULTS AND DISCUSSION

Data analysis was carried out using the smallest part structural equation model (PLS-SEM), which was assisted by the SMARTPLS 4.0 program. This method was chosen because it can test the causal relationship between independent variables (robotics technology and RFID) and dependent variables. This method can also be used to overcome sample size limitations. This study used a questionnaire on a Likert scale from 1 to 5 to evaluate sixteen indicators consisting of four research variables. Validity and reliability are tested before the main analysis to ensure the quality of the instrument. The external load criteria is more than 0.7, the AVE is more than 0.5, and the composite reliability is more than 0.7.

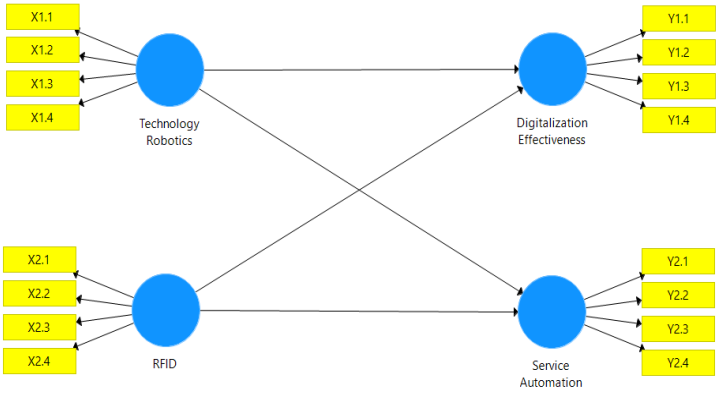

Figure 2. Research PLS Model

The results of the validity and reliability test showed that the data was worthy of further analysis. Validity and reliability tests have been carried out to ensure that the research tool can accurately and reliably measure the desired variables. According to the validity and reliability tests, the questionnaire showed a strong level of internal consistency, with the external charge criteria being more than 0.7, AVE more than 0.5, and composite reliability more than 0.7.

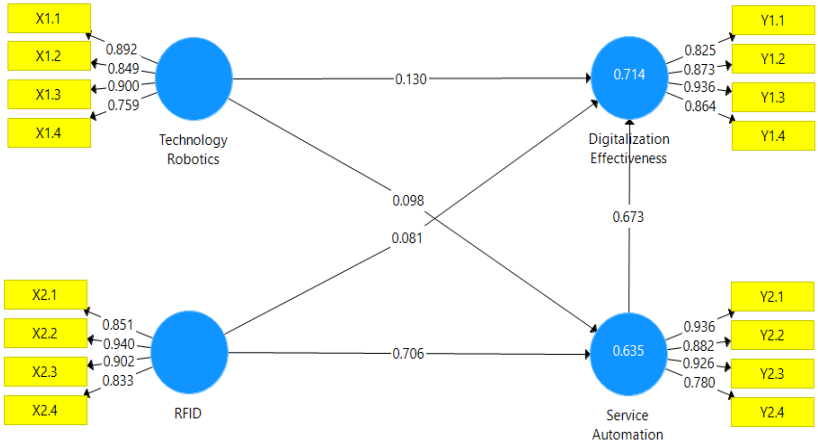

Figure 3. Result PLS Model

Figure 3 shows the measurement model for the validity and reliability test, as well as the determination coefficient and the path of the equation:

a. Validity Test

The data shows that the external load value for each indicator is more than 0.7. This indicates that each variable meets the conditions of convergent validity and that its indicators are explainable. In addition to the external load value, the extracted mean variance value (AVE) can also be used to determine the results of the convergent validity test. The AVE value for each latent construct must be greater than 0.5 to indicate a good measurement model.

Table 1. AVE and Reliability Tests

	Cronbach's Alpha	**rho_A**	**Composite Reliability**	**Average Variance Extracted (AVE)**
Digitalization Effectiveness	0,899	0,918	0,929	0,767
RFID	0,906	0,925	0,934	0,779
Service Automation	0,904	0,909	0,934	0,780
Technology Robotics	0,873	0,895	0,913	0,726

(Source: Researchers, 2025)

b. Reliability Test

Each construct is considered reliable because it has a composite reliability value between 0.6 and 0.7 and has a Cronbach's Alpha value of more than 0.7 (Sarstedt et al., 2011).

c. Test Model Fit

The following table 2 shows the value of R2.

Table 2. Test Model Fit

	R Square	R Square Adjusted
Digitalization Effectiveness	0,714	0,710
Service Automation	0,635	0,632

(Source: Researchers, 2025)

According to Table 2, the long-term R-value of the endogenous variable Digitization Effectiveness is 0.714, which shows the strength of the robotic variable and RFID technology in predicting Digitization Effectiveness is 71.4%. While the R-Square value of the endogenous variable of Service Automation is 0.635, which indicates the power of the robotic variable and RFID technology in predicting Service Automation is 63,5%.

d. Hypothesis Testing Analysis

The following Path Coefficient test results are the results:

Table 3. Hypothesis Test Results via Path Coefficient of Bootstrapping

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Service Automation -> Digitalization Effectiveness	0.673	0.669	0.067	10.105	0.000
RFID -> Digitalization Effectiveness	0.081	0.074	0.124	0.650	0.516
RFID -> Service Automation	0.706	0.710	0.083	8.468	0.000
Technology Robotics -> Digitalization Effectiveness	0.130	0.139	0.109	1.199	0.231
Technology Robotics -> Service Automation	0.098	0.096	0.098	1.003	0.316

(Source: Researchers, 2025)

1. The Effect of Service Automation on the Effectiveness of Digitalization in Logistics Services at PT Pos Indonesia (Persero).

The results of the study show that Service Automation can increase the effectiveness of digitization of PT Pos Indonesia (Persero) logistics services with a coefficient of 0.673, t-statistic 10.105, and P-value 0.000. ini show that Service Automation can increase the overall effectiveness of digitalization in PT Pos Indonesia (Persero)'s logistics operations and It is expected to improve the quality of operations, cost efficiency, and can raise the image of PT Pos Indonesia (Persero) in its implementation.

2. The Effect of RFID Technology on the Effectiveness of Digitalization in Logistics Services at PT Pos Indonesia (Persero).

The results of the study show that RFID technology increases the effectiveness of digitizing logistics services of PT Pos Indonesia (Persero) with a coefficient of 0.081, t-statistic 0.650, and P-value of 0.516. This shows that RFID can accelerate overall digitalization in logistics operations. Real-time tracking of goods, more accurate inventory management, and a more effective digital reporting system can be achieved with RFID technology. The opinion of Gaukler and Seifert (2007), who stated that RFID increases the visibility of the supply chain and enables the end-to-end digitization of logistics processes, supports this finding.

3. The Influence of RFID Technology on the Effectiveness of Automation Services of Logistics at PT Pos Indonesia (Persero).

The results showed that RFID technology significantly and positively affected the automation of logistics services, with a p-value of 0.000, a t-statistic of 8.468, and a coefficient value of 0.706. This suggests that the use of RFID directly improves automation systems, such as the automatic sorting, tracking, and distribution of goods. Data entering and exiting goods can be recorded automatically without manual intervention, so that the automation system can run more smoothly. These results are in line with the idea of Temjanovski (2020), who said that incorporating RFID into automation systems allows for a real-time work environment, zero errors, and efficient logistics.

4. The Influence of Robotic Technology on the Effectiveness of Digitalization in Logistics Services at PT Pos Indonesia (Persero).

The results of the study show that robotic technology has a positive and significant effect on the effectiveness of digitizing logistics services of PT Pos Indonesia (Persero) with a coefficient of 0.130, a t-statistical value of 1.199, and a p-value of 0.231. This means that the level of effectiveness of business digitalization is positively correlated with the level of optimization of robotic technology. It is proven that robotics improves the efficiency of digital services, reduces human error, and speeds up work processes, although the effect is not as big as other variables. Brynjolfsson and McAfee (2014) stated that more efficient and precise automated systems can replace manual activities and are able to speed up the digitization process.

5. The Influence of Robotic Technology on the Effectiveness of Logistics Service Automation at PT Pos Indonesia (Persero).

Based on the findings of the study, the automation of PT Pos Indonesia's logistics services is not too affected by robotic technology. A low coefficient value of 0.098, a t-statistic of 1.003, and a p-value of 0.316 all make this clear. This means that the use of robotic technology has not had a real impact on service automation. This may be due to limitations in the implementation of robotics that are not even across logistics service lines, or because the automation process still relies on other, more dominant technologies. In the theory of automation according to Groover (2001), automation can only run effectively if it is supported by strong and consistent system integration in the entire production process or service, including the software.

Thus, the results of the study show that RFID technology has a stronger and more consistent influence on both the effectiveness of digitalization and service automation compared to robotic technology, whose influence on automation is not significant.

CONCLUSION

The results of the study show that Radio Frequency Identification (RFID) technology supports the digitization and automation of PT Pos Indonesia (Persero) logistics services more strongly and significantly than robotic technology. The use of Radio Frequency Identification (RFID) technology has been proven to significantly improve the effectiveness of digitization through real-time tracking capabilities, inventory accuracy, and digital reporting efficiency, as well as strengthen service automation systems by enabling the sorting and distribution process to run automatically and with minimal errors. In contrast, robotic technology only has a significant influence on the effectiveness of digitalization but has not shown a significant influence on service automation. This is likely due to limited implementation and lack of system integration in the use of robotic technology. Thus, the integration of Radio Frequency Identification (RFID) technology is a key factor in driving digital transformation and automation of logistics services across the company.

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