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THE IMPACT OF BARCODE TECHNOLOGY, DECISION MAKING, AND RESOURCE EFFICIENCY ON PERFORMANCE IN OIL PALM COMPANY

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Abstract
This study aims to determine how barcode systems in oil palm firms impact overall performance, resource efficiency, and decision-making processes in the context of optimizing output. The research was conducted at PT Langkat Nusantara Kepong (PT LNK), a leading oil palm company in Indonesia, to provide a contextual understanding of digital integration in plantation management. A sample of 424 employees was selected using proportional random sampling from April 2024 to June 2024. Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The findings reveal that the Barcode System significantly influences resource efficiency and decision-making, which in turn positively affect overall company performance. However, the Barcode System does not have a direct effect on performance; its impact is mediated through improvements in resource efficiency and decision-making. These results suggest that while the implementation of a barcode system is not a standalone solution, it can be a powerful enabler of performance enhancement when coupled with effective resource utilization and informed decision-making. Practically, this implies that management at PT LNK and similar firms can leverage barcode technology to optimize operations, improve traceability, and support strategic planning by focusing on strengthening internal capabilities that mediate its benefits.

Keywords: *Agribusiness Management, Barcode System, Decision Making, Oil Palm Company, Performance Improvement, Resource Efficiency.*

1. INTRODUCTION

The palm oil business faces the difficulty of increasing output while optimizing resource allocation. Traditional methods with manual recording have limitations and demand creative ways to improve the overall performance and sustainability of oil palm firms (Nohara et al., 2021). PT. Langkat Nusantara Kepong (PT LNK), a prominent palm oil company in Indonesia, has historically relied on manual data recording methods that often result in delayed information flow, human error, and inefficiencies in resource tracking. These manual approaches hinder productivity and make it difficult to make timely and accurate decisions, particularly in managing large-scale plantation operations. This has posed significant challenges in terms of monitoring harvest yields, identifying underperforming blocks, and managing labor distribution efficiently. Therefore, the objective of this study is introduced early: to determine how the use of barcode systems at PT LNK impacts overall performance, resource efficiency, and decision-making processes in the context of optimizing operational output. As a result, creative ways to improve the overall performance and sustainability of oil palm firms are urgently needed.

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To achieve a seamless and effective transfer from traditional manual recording to a barcode-driven data management system, a thorough training program for field staff is required (Kubáňová et al., 2022). One of the most significant benefits of the barcode system is its capacity to collect real-time data during various phases of palm oil production. Harvesters fitted with barcode scanners directly enter crucial information into the system, such as the harvest quantity, seed quality, and rotation parameters. This real-time data collection not only decreases the possibility of mistakes but also provides up-to-date insights for more accurate planning and forecasting (Sinambela et al., 2020).

In addition to its role in harvest logistics, the barcode system adds greatly to quality control procedures. Individual harvesters and their yields can be identified by the system, allowing for targeted quality evaluation. Furthermore, by integrating expert systems for oil palm disease diagnosis, the barcode system can assist in the early identification and treatment of plant diseases (Choudhary et al., 2021). This proactive method protects the health of palm oil plantations, allowing for long-term high-quality production.

The data collected by the barcode system are a goldmine for performance analytics. Managers can estimate the productivity of specific planting blocks by analyzing individual and collective harvester performance, identifying trends in crop rotations, and identifying patterns in crop rotations. This analytical competence allows data-driven decision-making for continuous improvement plans, allowing oil palm enterprises to quickly react to changing market needs and environmental issues (Singh et al., 2023).

The barcode system is critical in enabling visibility across the entire palm oil supply chain when customers expect transparency and sustainability. Companies that employ ethical and ecological business practices may use the system to track the origin of each batch of palm oil, ensuring compliance with the certification criteria. This satisfies customer expectations and provides opportunities for market distinctiveness and premium pricing (Wang et al., 2022).

Although barcode systems have several advantages, problems such as initial installation costs, technological infrastructure needs, and data security concerns must be solved. Furthermore, continuous advances in information and communication technologies (ICT) may provide opportunities for additional improvements and incorporation of new technologies, such as blockchain, to increase traceability (Kumar et al., 2019).

The experience of PT LNK in adopting barcode technology provides a real-world context to examine the transition from manual to digital systems in the palm oil sector (Zulham et al., 2023a). The use of the barcode system in the palm oil sector symbolizes a paradigm shift toward operational excellence, resource efficiency, and environmentally responsible production techniques. PT. Langkat Nusantara Kepong (LNK) is a real-world illustration of the impact of this technology (Zulham et al., 2022). Acceptance of novel solutions, such as the barcode system, as the sector advances, not only answers present difficulties, but also places palm oil producers at the forefront of responsible and efficient farming practices. The purpose of this study is to determine how the use of barcodes by oil palm firms impacts overall performance, resource efficiency, and decision-making processes in the context of optimizing output.

Smart Agriculture is the most recent paradigm, based on agricultural data. This is the result of advancements in telecommunication and data processing. We were familiar with the term Precision Farming, which was used to improve operational accuracy. Smart farming is based on the same principles as Precision Agriculture, namely collection and data analysis, to draw appropriate managerial conclusions. Farmers must visit farms, as opposed to traditional methods, to check the state of the plot and review the decisions made without their knowledge. Many factors contribute to the ineffectiveness of this method, including the fact that many sectors are too broad to be adequately addressed (Abu et al., 2022).

Different types of agricultural digitalization have given rise to a number of concepts. These include

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Smart Farming (Blok and Gremmen, 2018; Wolfert et al., 2017), and Accuracy Agriculture (Eastwood et al., 2017). Whatever the precise term may be, it points to the application of drones, machines, and satellites for monitoring weather, sanitation, location, energy use, value, and information regarding animals, soil, plants, and people on and off farms. The gathered information is then used to draw conclusions about the past and make predictions about the future, allowing for better, more timely, and more precise decision making (Wolfert et al., 2017; Eastwood et al., 2017).

Agricultural digitization is expected to improve the production systems of farming, food systems, and value chains. Digitization is also expected to better controlling conjuncture and conflict in the agricultural sector as well as increase knowledge exchange (Stevens et al., 2016). One aspect of digital agriculture is its use of barcodes.

Barcodes offer many benefits, such as limiting the amount of paper used in transactions. A barcode can be interpreted as a set of codes represented by lines, where the thickness of each line varies with its meaning. The barcode encodes numbers and letters using a combination of bars and spaces with different variations. A Barcode contains information encoded according to specific conventions, and a graphic that represents the information in a barcode field that includes colored stripes or non-colored bars and spaces. Usually, barcodes do not contain descriptive data but consist of a different number of digits or characters, depending on the type of barcode that makes up a reference number. The barcode information is stored in the form of datasets that can be classified and retrieved to handle numbers or characters in electronic data processing.

Barcode system technology is a widely used application system in many different types of businesses. This technology is used in areas such as health, security, animal husbandry, and agriculture in addition to inventory systems. In agriculture, the use of barcodes has also greatly aided in the identification of agricultural products; therefore, the barcode system has made a significant contribution to the improvement of the supply chain management system. According to Braun et al. (2018), by combining technologies, simple technologies such as Bluetooth, GPS, and barcodes can turn challenges into opportunities for supply chain management.

2. METHOD

2.1 Research Model and Hypotheses

The implementation of barcode technology brings a myriad of significant benefits, particularly in terms of resource efficiency. The automated process utilizing barcodes enables harvesters to quickly and accurately record crucial information, such as the quantity of harvest, seed quality, and details of crop rotation. By reducing human involvement in manual recording, this technology saves time and minimizes the risk of errors (Istiqomah et al., 2020).

Barcodes allow for more efficient monitoring in inventory management. Real-time data collection provides accurate insights into inventories, enabling companies to optimize resource allocation, such as fertilizers and pesticides, based on actual needs and crop conditions. This will help achieve more effective and efficient inventory management (Dhanaraju et al., 2022).

In the context of decision making, barcode technology provides access to real-time data during palm oil production. This information serves as the foundation for quick and accurate decision-making by management. Data on harvest results, seed quality, and crop rotations offer critical insights for production planning and better crop management strategies (Finger et al., 2019).

Furthermore, barcode technology opens up opportunities for in-depth performance analysis. The collected data can be used to assess the individual and collective performance of harvesters, identify patterns in crop rotations, and evaluate the productivity of specific planting blocks. This analysis provides the basis for data-driven decision making aimed at improving overall efficiency

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and productivity (Darguza & Gaile, 2023).

In terms of performance, the implementation of barcode technology creates consistency in daily tasks such as recording harvest results and managing inventory. This consistency contributes to the enhancement of company performance overall. Additionally, accurate and consistent monitoring from the barcode system can improve the satisfaction of harvesters and management, as the available information provides a clear overview of the performance and production results. The increase in productivity obtained through the reduction of manual recording time and minimization of human errors creates a more efficient and effective work environment, which positively impacts the overall performance of the company (Nisa & Rahmawati, 2023).

Several previous studies have demonstrated this phenomenon. According to Gozi and Felicia (2019), ICT use can affect employee performance quality. Because employee performance is a component of company performance, it is reasonable to conclude that ICT can improve company performance. Therefore, our research model is shown in Figure 2.

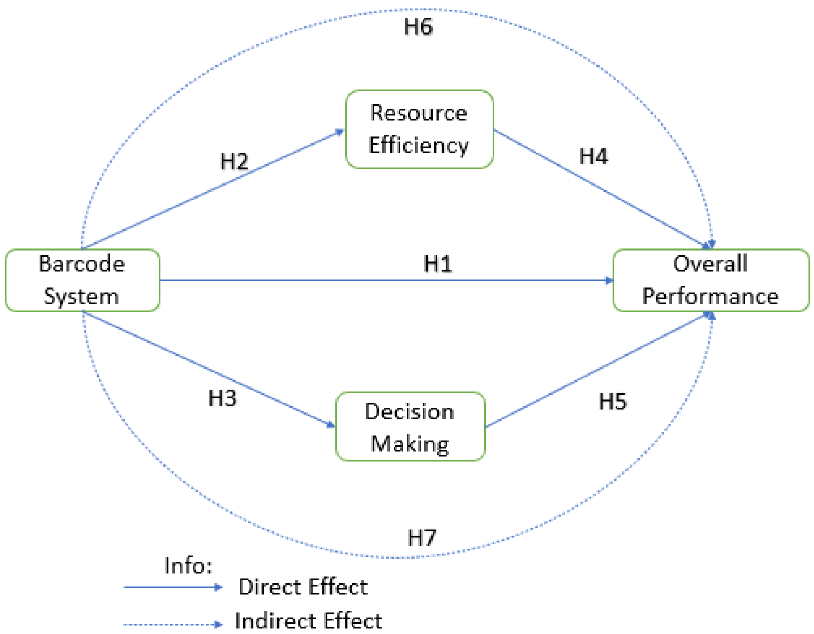

Figure 2 Research Model

Based on the research model in Figure 2, it can be written all the hypotheses being used in this study, ie:

H1: Barcode System has a positive effect on Overall Performance.

H2: Barcode System has a positive effect on Resource Efficiency.

H3: Barcode has a positive effect on Decision Making.

H4: Resource Efficiency has a positive effect on Overall Performance.

H5: Decision Making has a positive effect on Overall Performance.

H6: The Barcode System has a positive indirect effect on Overall Performance Through Resource Efficiency.

H7: The Barcode System has a positive indirect effect on overall performance through decision-making.

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2.2 Data Collection

Primary data were collected during this investigation. Facts and figures obtained through in-depth interviews with workers. The research was carried out for 3 (three) months, from April to June 2024, in an oil palm company, PT Langkat Nusantara Kepong. The sample of this research was chosen by four estates of that company: Basilam, Bekium, Padang Brahrang, and Gohor Lama Estates. The total sample comprised of 424 employees.

2.3 Data Analysis

Partial least squares structural equation modeling (PLS-SEM) was employed in this study to conduct a comprehensive analysis of the data. This technique is particularly useful for testing hypotheses related to the direct and indirect relationships between variables, combining the strengths of regression and path analysis in handling complex models. This analysis can describe the relationship between the dependent and independent variables in a single comprehensive analysis. To execute PLS-SEM, the SMARTPLS 4 program was utilized, providing a robust platform for this sophisticated statistical approach.

According to Hair et al. (2017), PLS-SEM offers several advantages that enhance its applicability in diverse research scenarios. First, PLS-SEM can effectively operate complex models, accommodating a large number of dependent and independent variables without compromising the integrity of the analysis. Additionally, it excels in processing data plagued by multicollinearity issues among the independent variables, ensuring the reliability of the results. One notable strength of PLS-SEM is its capability to handle datasets with missing or abnormal data, producing robust and reliable results, even in less-than-ideal data scenarios. This feature contributes to the versatility of PLS-SEM, making it suitable for both retrospective and prospective research.

Moreover, PLS-SEM is valuable for dealing with non-normally distributed data and small sample sizes. Its flexibility in accommodating different data scales adds to its utility in diverse research contexts. The application of PLS-SEM, facilitated by the SMARTPLS 4 program, provides a powerful and versatile analytical framework for exploring the complex relationships between variables in this study. Its ability to handle intricate models, address data challenges, and accommodate various types of data scale positions makes PLS-SEM a robust statistical tool in the realm of research methodology.

Partial Least Squares (PLS) comprises both a measurement model and a structural model. The measurement model relies on the correlation between the latent and observed variables. Simultaneously, the structural model aims to elucidate the connections between the latent variables. Therefore, ensuring the validity and reliability of the measurement model is crucial, and the significance of the path coefficients and explanatory power are assessed in the structural model.

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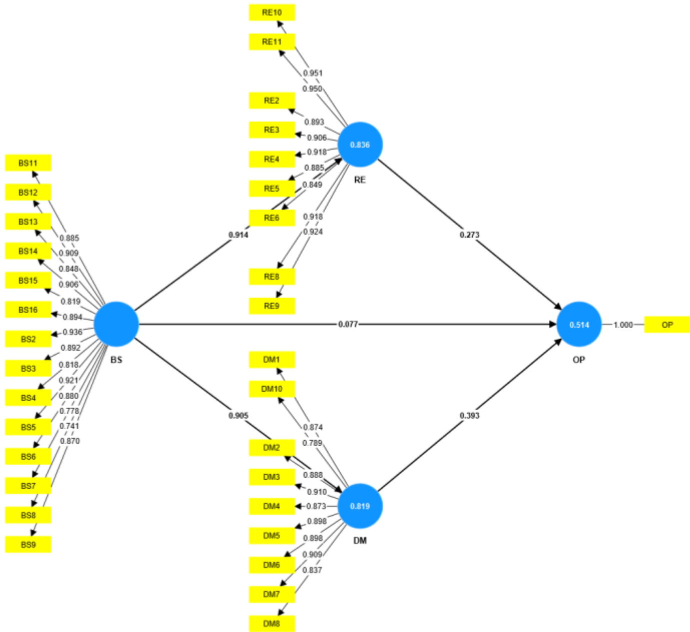

Figure 1. PLS Model After Loading Factor Analysis

In Figure 1, it is evident that all the questionnaire items had values above 0.700. Questionnaire items with loading factor values below 0.700 were eliminated as they were considered invalid. This elimination process enhances the reliability and validity of the measurement model, ensuring that the selected items effectively represent underlying latent variables. The robustness of the measurement model is essential for the accurate interpretation and analysis of the structural model's findings.

The initial phase involves evaluating the outer reflective indicator model based on three criteria: convergent validity, composite reliability, and discriminant validity. Convergent validity is determined by the Average Variance Extracted (AVE) values, while composite reliability is assessed using rho_a and rho_c. Convergent validity, as measured by AVE, provides insights into the extent to which the indicators of a latent variable converge. A higher AVE value indicates stronger convergent validity, suggesting that the indicators effectively measured the underlying construct.

Composite reliability, evaluated using rho_a and rho_c, assesses the internal consistency and reliability of the latent variable. Higher values of rho_a and rho_c signify greater reliability, indicating that the indicators collectively contribute to a reliable measurement of the latent variable. This offers a comprehensive understanding of the quality and reliability of the outer reflective indicator model, ensuring that the measurement model effectively captures the intended constructs with precision and consistency.

Table 1. Construct Reliability and Validity

Variable	Cronbach's alpha	rho_a	rho_c	AVE	Decision
Barcode System	0.974	0.976	0.977	0.750	Valid
Decision Making	0.962	0.962	0.967	0.767	Valid
Resource Efficiency	0.974	0.976	0.978	0.830	Valid

Discriminant validity is evaluated based on cross-loading values, where each indicator ideally exhibits a higher loading on its designated latent variable than on other latent variables in the model. In this study, it was ensured that no item had a loading value higher than that of any other variable.

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This practice is essential to confirm that each indicator measures the latent variable it is intended to represent and is not strongly associated with other variables in the model. Cross-loading values provide insights into the uniqueness of each indicator in relation to its assigned latent variable, thus supporting the discriminant validity of the measurement model.

If errors are identified, correction steps may involve revisiting the measurement model and assessing whether there are indicators with high cross-loadings. If such instances are found, adjustments to the model, such as refining item wording, revising indicator assignments, or considering additional indicators, may be necessary to enhance the discriminant validity. Regular checks and refinements of the model during the research process can help ensure the robustness and accuracy of the measurement model.

Once all prerequisites are satisfied, the subsequent step involves evaluating the inner model with a focus on assessing the R-squared values. The R-squared value was employed to gauge the significance of the dependent latent variables. In this analysis, the decision-making variable registered an R-squared value of 0.819, indicating a high level of explanatory power. For the overall performance, the R-squared value was 0.514, suggesting a moderate level of explanatory capability. Meanwhile, resource efficiency demonstrated a robust R-squared value of 0.836, emphasizing a substantial explanatory influence in the model. These R-squared metrics serve as crucial indicators for understanding the variance and effectiveness of latent variables within the inner model.

3. RESULT AND DISCUSSION

The results of the hypothesis testing are shown in Table 1. In hypothesis testing, we used 1.96value in t-table for alpha 5%. When the result is T table < T value, the hypothesis is accepted, and it is rejected if T table> T value. Table 2 presents the test results (Hair et al., 2021).

Table 2. Hypothesis testing results

Path	Std. Beta	Std. Error	T-values	P-values	Hypotheses
BS -> DM	0.905	0.013	69.650	0.000	Received
BS -> OP	0.077	0.134	0.578	0.564	Rejected
BS -> RE	0.914	0.016	56.368	0.000	Received
DM -> OP	0.393	0.089	4.423	0.000	Received
RE -> OP	0.273	0.098	2.777	0.006	Received
BS -> DM -> OP	0.355	0.082	4.316	0.000	Received
BS -> RE -> OP	0.250	0.089	2.807	0.005	Received

Note: *t(0.05): 1.96

This research examined several hypotheses related to the relationship between the Barcode System (BS), decision-making (DM), Resource Efficiency (RE), and Overall Performance (OP) in the context of the oil palm industry. The results and interpretations of each hypothesis-testing path are as follows.

First, the positive and significant impact of the Barcode System on Decision Making (DM) was found (p-value = 0.000), indicating that the Barcode System makes a substantial contribution to influencing the decision-making process. This result highlights the crucial role of the Barcode System in providing information that supports more effective and efficient decision-making (Li et al., 2022).

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Meanwhile, the hypothesis test regarding the impact of the Barcode System on Resource Efficiency (RE) showed significant results (p = 0.000). This indicates that the implementation of the Barcode System contributes positively to the efficiency of resource usage in the operational processes of oil palm companies. The Barcode System helps manage inventory and harvesting processes more efficiently, creating sustainability in resource utilization (Zulham et al., 2022). This is supported by Miralam's (2017) study, which indicates that, through the integration of barcode technology, oil palm enterprises can enhance operational efficiency, minimize errors, improve inventory control, optimize asset utilization, and establish superior traceability and quality management across the entire production cycle.

However, a different finding emerged when testing the relationship between the Barcode System (BS) and the Overall Performance (OP), where the result was not significant (p = 0.564). This indicates that while the Barcode System supports certain operational improvements, these may not be sufficient on their own to drive overall performance gains. One possible explanation is the early stage of implementation at the company, where full integration and user adaptation have not yet matured. Additionally, user resistance or lack of cross-departmental system integration may hinder the Barcode System’s direct effect on performance.

Decisions made through the decision-making (DM) process were found to have a positive and significant impact on the Overall Performance (OP) of the company (p-value = 0.000). This emphasizes the importance of informed and effective decision-making in achieving good overall performance. Informed and effective decisions can provide better guidance to achieve a company's goals.

The level of Resource Efficiency, measured through resource efficiency (RE), also contributed positively to the Overall Performance (OP) of the company (p-value = 0.006). This indicates that a focus on resource management efficiency can positively impact overall performance.

The path analysis involving Barcode System, Decision Making, and Overall Performance showed that the Barcode System not only directly influences Decision Making but also has a positive impact on overall performance through the decision-making process (p-value = 0.000). This path underscores the crucial role of the Barcode System in supporting decisions that lead to improved overall company performance (Zulham et al., 2023b).

Furthermore, hypothesis testing regarding the path from the Barcode System to Resource Efficiency, and subsequently to Overall Performance, also yielded significant results (p-value = 0.005). This demonstrates a quantifiable indirect effect of the Barcode System on overall performance, confirming its influence through intermediary variables such as resource efficiency and decision-making. Overall, these findings provide valuable insights into optimizing operational practices, decision making, and resource efficiency in the oil palm industry through the implementation of Barcode System technology. Despite these insights, the readiness of human resources to adopt and operate the barcode system is a critical factor that requires attention. Field operators and staff may lack the technical skills or motivation to adopt new digital tools, highlighting the importance of structured training programs and change management strategies.

This study contributes to the development of an oil palm company’s barcode system. This study shows that the barcode system can be used for agribusiness management in an oil palm company to improve performance. Overall performance is strongly influenced by resource efficiency and decision making, meaning that an increase in these two variables will increase overall performance (Qaim et al., 2020). Therefore, it is recommended that companies integrate the barcode system with ERP platforms, implement comprehensive staff training, and establish performance monitoring systems to ensure full adoption and long-term effectiveness of the technology (Siregar et al., 2024).

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4. CONCLUSION

Barcode technology plays a crucial role in providing information that supports decision-making and helps companies manage the harvesting process more effectively and efficiently. Although the barcode system contributes to decision making and resource efficiency, its impact does not automatically translate into an overall performance improvement; it must occur through enhancements in other variables or indirect influences. Informative and effective decision making underscores the importance of the decision-making process in achieving overall excellence. The focus on efficiency in resource management has proven to have a positive impact on overall performance. To maximize the benefits of the barcode system, companies should invest in employee training and ensure user readiness to operate and adapt to the technology effectively. This includes providing technical support, regular system evaluations, and fostering a culture of digital adoption within the organization.

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