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Development of a Warehouse Performance Measurement Framework for PT X Using the Warehouse Key Performance Indicators (WKPI) Model

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ABSTRACT

This study aims to develop a warehouse performance measurement framework and measure the performance of PT X's warehouse using the Warehouse Key Performance Indicators (WKPI) model, as the warehouse previously lacked a structured performance measurement system. A screening process was conducted on 41 WKPI indicators, resulting in 10 indicators that were considered relevant to the warehouse operations. The indicators were weighted using the Analytical Hierarchy Process (AHP), while warehouse performance was measured using the Snorm De Boer Scoring System. Furthermore, the Traffic Light System (TLS) was employed to classify the level of performance achievement. The results indicate that the quality dimension obtained the highest weight among all dimensions. The performance measurement generated an average warehouse performance score of 85.71%, indicating that the overall performance of PT X's warehouse was satisfactory. However, the TLS analysis revealed that order picking time and order lead time remained in the red category, indicating the need for performance improvement. Therefore, Root Cause Analysis (RCA) was conducted to identify the underlying causes of the performance gaps and to formulate improvement recommendations. The proposed improvements are expected to enhance the operational performance of the warehouse.

INTRODUCTION

Every company needs a lot of archives to support operational activities, administration, audits, and business legality. Archives function as a source of reference or memory, a basis for decision-making, a legal evidence tool and historical reference (Sugiaryo & Wahyono, 2005), so they must be managed properly so that they can be accessed quickly and precisely when needed. According to the Law of the Republic of Indonesia Number 43 of 2009 concerning Archives, archives are recordings of activities or events in various forms and media made and received by state institutions, local governments, educational institutions, companies, organizations and individuals in the implementation of community, nation and state life. Meanwhile, Fathurrahman (2018) explained that archives are records of information from organizational activities that function as a memory center, decision-making tool and evidence of the organization's existence. Documents are categorized as archives if they contain important information that is useful in the past, present, and future (Rosalin, 2017).

Based on their function, archives can be divided into 2 (two), namely static archives and dynamic archives (Sugiaryo & Wahyono, 2005). Dynamic archives are archives that are

used directly in organizational operational activities and have high use value in administrative activities. In Law of the Republic of Indonesia Number 43 of 2009 concerning Archives, dynamic archives are further divided into two, namely active archives and inactive archives. Active archives are archives that have a high and/or continuous frequency of use. Meanwhile, inactive archives are archives whose frequency of use has decreased and are rarely used for the implementation of company administration and are only used as reference materials or just wait until the end of their storage period according to the Archive Retention Schedule (JRA).

PT X produces a large volume of archives every year. Operational activities involving various transactions, agreements, reports and other documents cause PT X to produce an increasing number of archives. At PT X, inactive archives originating from various functions are handed over to Function A to be managed and stored in the archive warehouse so that they can be accessed again through requests if needed for the audit process or other interests, Based on PT X's internal data, the number of inactive archive boxes managed by Function A shows a consistent increasing trend in the past year.

Throughout 2024, the number of boxes of inactive archival documents stored in PT X's warehouse shows a consistent upward trend. In the first quarter, there were 9,758 boxes, then increased to 10,083 boxes in the second quarter, 10,546 boxes in the third quarter, and reached 10,843 boxes in the fourth quarter. This growth reflects the increasing storage load and the increase in archive handling activities in warehouses. If the increase in archive volume is not balanced with an adequate management and performance measurement system, this condition has the potential to reduce operational efficiency, slow down the document search process, and reduce the quality of service to archive users. In addition to the increasing number of archives, the process of fulfilling document requests also still faces obstacles that have an impact on service delays.

An evaluation of the order processing time shows that the average time from the time the customer makes the request to the receipt of the document always exceeds the Service Level Agreement (SLA) limit set by the company, which is 3 business days. During 2024, the average service time for each quarter will reach 3.47 days in the first quarter, 3.72 days in the second quarter, 3.55 days in the third quarter, and 3.64 days in the fourth quarter. This condition indicates that the operational process of the archive warehouse has not run optimally, especially in the search, processing, and distribution of documents. This delay has the potential to disrupt the smooth running of internal business processes while reducing user satisfaction with the archive management services provided by PT X.

In the modern supply chain system, warehouses no longer only function as storage places, but also as strategic parts that provide added value to the organization through inventory management, service, and operational efficiency. Therefore, a Warehouse Performance Measurement (WPM) system is needed that is able to evaluate warehouse performance as a whole using Key Performance Indicators (KPIs) (Liviu et al., 2009). One of the widely used models is the Warehouse Key Performance Indicators (WKPI) developed by Staudt et al. (2015), with four main dimensions, namely time, cost, quality, and productivity. This approach allows companies to identify operational weaknesses, evaluate the effectiveness of resource use, and determine improvement priorities to improve the quality of warehouse services.

Based on these conditions, this study aims to design a performance measurement system for PT X's inactive archive warehouse using the WKPI model combined with the Analytical Hierarchy Process (AHP) method to determine the weight of indicators and the Traffic Light System (TLS) to evaluate the level of performance achievement. The research is focused on the preparation of performance measurement designs, analysis of warehouse operational conditions, and the preparation of improvement recommendations that can be applied by the company. The results of the research are expected to be able to provide an objective picture of the performance of PT X's inactive archive warehouse, become the basis for continuous operational evaluation, and support the development of strategies to improve the efficiency, effectiveness, and quality of archive management services in the future.

METHOD

The research method begins with data collection through literature studies and field studies. A literature study was conducted to obtain a theoretical basis regarding Warehouse Key Performance Indicator (WKPI) by Staudt et al. (2015), Analytical Hierarchy Process (AHP), Scoring System, Traffic Light System, and Root Cause Analysis (RCA). Meanwhile, field studies were carried out through observation and interviews with PT X's internal parties to understand the process of warehousing inactive archives, operational conditions, and obtain the necessary data. The results of the data collection are the basis for identifying warehousing activities and determining performance indicators that are in accordance with the company's conditions.

The next stage is the design of a warehouse performance measurement system using the WKPI model by Staudt et al. (2015) and the AHP method by Saaty (2000). The WKPI model is used to select relevant performance indicators based on four dimensions, namely time, cost, quality, and productivity, through a screening process using questionnaires to parties involved in archive management. The selected indicators are then arranged in a hierarchical structure and weighted using the AHP method through paired comparisons processed with the Expert Choice software. Furthermore, the results of the selection of indicators and weighting were validated with the company's internal parties to ensure their suitability with the operational conditions of PT X's inactive archive warehouse.

The final stage of the research is the measurement and evaluation of warehouse performance based on validated indicators and weights. The value of each indicator is calculated according to the WKPI formulation, then normalized using the De Boer method and classified with the Traffic Light System by Vanany et al. (2005) to determine the level of performance achievement. Indicators that have not reached the target are further analyzed using Root Cause Analysis (RCA) with fishbone diagrams to identify the main cause of the problem. Based on the results of the analysis, conclusions and recommendations for improvement that can be used by PT X as a basis for improving the performance of the management of inactive archive warehouses are prepared.

RESULTS AND DISCUSSION

Overall Performance of PT X's Inactive Archive Warehouse

The performance measurement of PT X's inactive archive warehouse was carried out to determine the overall level of performance achievement based on all indicators that have been determined. Based on table 4.9, the performance value of PT X's inactive archive warehouse in the first quarter was 85.89%, then decreased to 83.64% in the second quarter. In the third quarter, the performance value increased to 87.12% and decreased to 86.18% in the fourth quarter. The average performance value during 2024 reached 85.71%. Although there is a difference in value between quarters, the difference that occurs is not too large, so it shows that the performance of the archive warehouse can be maintained quite well throughout 2024.

Table 1. Results of Outstanding Performance of PT X's Inactive Archive Warehouse WKPI in 2024

No	None next	Code	Indicator	WKPI Achievement				Weighted WKPI Value			
				Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV
1	Time	T1	*Order picking time*	68,56 %	57,53 %	66,28 %	58,29 %	3,77 %	3,16 %	3,65 %	3,21 %
2		T2	*Order lead time*	63,29 %	57,01 %	61,16 %	58,92 %	11,58 %	10,43 %	11,19 %	10,78 %
3		T3	*Retention Disposition Timeliness*	97,93 %	92,32 %	97,78 %	94,11 %	4,90 %	4,62 %	4,89 %	4,71 %
4	Product ivity	P1	*Inventory utilization*	76,53 %	79,08 %	82,71 %	85,04 %	8,88 %	9,17 %	9,59 %	9,87 %
5		P2	*Warehouse utilization*	94,76 %	95,61 %	96,47 %	97,33 %	3,70 %	3,73 %	3,76 %	3,80 %
6	Cost	C1	*Transportation cost*	99,78 %	113,71 %	110,42 %	117,11 %	8,08 %	9,21 %	8,94 %	9,49 %
7	Quality	Q1	*Physical inventory accuracy*	99,50 %	99,17 %	99,67 %	99,41 %	4,48 %	4,46 %	4,49 %	4,47 %
8		Q2	*Orders shipped accuracy*	100,26%	100,75 %	100,85 %	100,86 %	22,36 %	22,47 %	22,49 %	22,49 %
9		Q3	*Orders shipped on time*	68,56 %	61,93 %	69,44 %	65,73 %	5,21 %	4,71 %	5,28 %	5,00 %
10		Q4	*Customer satisfaction*	98,03 %	88,49 %	97,23 %	93,73 %	12,94 %	11,68 %	12,83 %	12,37 %
Achievement of WKPI PT X's Inactive Archive Warehouse								85,89 %	83,64 %	87,12 %	86,18 %

Based on table 1, the results of PT X's inactive archive warehouse performance measurement show that most of the indicators have been in the green category during the 2024 measurement period. In the first quarter, there were six indicators in the green category and four indicators in the yellow category. In the second quarter, there were six indicators in the green category, two indicators in the yellow category and two indicators in the red category. In the third quarter, there were seven indicators in the green category and three indicators in the yellow category. In the fourth quarter, there were seven indicators in the green category, one indicator in the yellow category and two indicators in the red category.

When reviewed based on the WKPI dimensions, the *quality* Shows the best performance during the measurement period. This can be seen from the indicator *physical inventory accuracy* (Q1), *orders shipped accuracy* (Q2) dan *customer satisfaction* (Q4) which is consistently in the green category. On the dimensions *cost*, indicator *transportation cost* (C1) also shows good achievements and above the target. Meanwhile, in the *productivity*, indicator *warehouse utilization* (P2) is in the green category for the rest of the quarter, while *inventory utilization* (P1) shows a gradual increase from the yellow category in the first 2 quarters to the green category in the last 2 quarters.

In contrast to other dimensions, the *Time* shows lower realistic results, indicators *order picking time* (T1) and *order lead time* (T2) is still in the red category for most of the measurement period, while *retention disposition timeliness* (T3) is consistently in the green category. This realization illustrates that the challenge in managing PT X's inactive archive warehouse lies in the speed of the service process to customers, especially in the search process, and the provision requested. In general, the results of the study show that the main strength of PT X's inactive archive warehouse is in the *quality, cost* and some indicators on the dimensions *productivity*. On the other hand, the dimensions *Time* It is still an area that needs further attention because not all indicators have been able to achieve the set targets. Further analysis of each of the performance indicators is presented in the next sub-chapter.

Analysis of Performance Measurement Results by Indicator

The measurement results show that the level of achievement in each performance indicator has different variations illustrating that each indicator is affected by different operational conditions and characteristics of warehouse activities. The discussion in this sub-chapter is focused on identifying the factors that affect the achievement of each indicator and explaining its influence on the performance of PT X's inactive archive warehouse as a whole.

High-Performance Indicator (Green)

High-performance indicators are indicators that consistently achieve targets and are in the green category during the measurement period, indicators that are included in the green category are *retention disposition timeliness* (T1), *warehouse utilization* (P2), *transportation cost* (C1), *physical inventory accuracy* (Q1), *orders shipped accuracy* (Q2) and *customer satisfaction* (Q4).

The *retention disposition timeliness* (T3) indicator is in the green category during the fourth quarter of measurement with consecutive realizations in each quarter of 97.93%, 92.32%, 97.78% and 94.11%. Despite fluctuations in value from quarter to quarter, the achievement of this indicator remains within the set target range. These results show that the

archive disposition process has been carried out in accordance with the Archive Retention Schedule (JRA) so that the management of the archive life cycle can run well

The *warehouse utilization* (P2) indicator was consistently in the green category during the measurement period with achievement values ranging from 94.76% to 97.33%. This achievement shows that the capacity of the archive warehouse has been well utilized without exceeding the available capacity limit. The appropriate level of space utilization also shows that archive storage can still be done optimally and provides enough space for additional archives in the next period.

The *transportation cost* indicator (C1) was in the green category for four quarters of measurement. The achievement value increased from 99.78% in the first quarter to 117.11% in the fourth quarter. These results show that the transportation cost of shipping the orders issued is still within the limit of IDR 500,000 per order so that transportation cost efficiency can be maintained.

The *physical inventory accuracy* (Q1) indicator was in the green category throughout the quarter, namely 99.50% in the first quarter, 99.17% in the second quarter, 99.67% in the third quarter and 99.41% in the fourth quarter. These results show that the harmony between the inventory data and the physical condition of the archive box is well maintained, although there are still some physical boxes that are not in the proper storage location, the difference between the actual value and the target is relatively small so that it does not have a significant influence on the overall inventory accuracy.

The *orders shipped accuracy* (Q2) indicator obtained an achievement value of 100.26% in the first quarter, 100.75% in the second quarter, 100.85% in the third quarter and 100.86% in the fourth quarter. This achievement shows that the archive box sent to the user has been in accordance with the request so that errors in the delivery of the archive box can be minimized. Although there are still archive boxes that are not in accordance with the order, the number is relatively small compared to the total archives sent. In other words, in each order there are still around 1-3 archive boxes that are not suitable, but these conditions are still above the set target of 95%.

The *customer satisfaction* indicator (Q4) was in the green category throughout the measurement quarter with an achievement value of 98.03% in the first quarter, 88.49% in the second quarter, 97.23% in the third quarter, and 93.73% in the fourth quarter. These results show that users are generally satisfied with the services provided by PT X's inactive archive warehouse. This shows that the accuracy and speed of archive services are one of the factors that affect customer satisfaction with archive box ordering services.

Medium Performance Indicator (yellow)

A medium-performance indicator is an indicator that has not consistently achieved the set target, but is still at a fairly good level of performance. In the results of this study, there are two indicators that are included in the yellow category, namely *inventory utilization* (P1) and *orders shipped on time* (Q3). Both indicators show that there are opportunities for improvement to improve the performance of PT X's inactive archive warehouse.

1. The *inventory utilization* indicator (P1) obtained an achievement value of 76.53% in the first quarter, 79.08% in the second quarter, 82.71% in the third quarter, and 85.04% in the fourth quarter. These results show an increase in storage capacity utilization. In the first two quarters, this indicator was still in the yellow category because the storage capacity utilization rate had not reached the target of 85%. Along with the increase in archive boxes, the utilization value continued to increase until it reached the green category in the fourth quarter. This realization shows that the storage capacity of the archive warehouse is still sufficient to accommodate the addition of incoming archive boxes in the next period.
2. The *orders shipped on time* (Q3) indicator obtained an achievement value of 68.%^% in the first quarter, 61.93% in the second quarter, 69.44% in the third quarter, and 65.73% in the fourth quarter. During the measurement period, this indicator is in the yellow category which indicates that the timeliness of sending the archive to the user has not fully reached the set target. The lowest score occurred in the second quarter, while in the third quarter and fourth there was an increase even though it was not able to reach the green category. The realization of this indicator shows that most orders have been fulfilled according to the set time, but there are still a number of orders that are delayed. These conditions can be affected by the time it takes to find and prepare an archive before it is sent to the user. This can be seen from the achievement of *order picking time* (T1) which also shows a relatively low value during the measurement period. Thus, the increase in order timeliness depends not only on the distribution process, but is also affected by the speed of the search and supply process within the warehouse.

Improvement Priority Indicator (Red)

The improvement priority indicator is an indicator that has the lowest level of achievement compared to other indicators. In this study, there are two indicators that are included in the red category, namely *order picking time* (T1) and *order lead time* (T2). Both indicators are in the *time dimension* and are directly related to the speed of archive services to users. The realization that has not been optimal in these two indicators shows that the process of searching, retrieving, and providing archives still needs attention to improve the overall performance of the warehouse.

1. The *order picking time* (T1) indicator obtained an achievement value of 68.56% in the first quarter, 57.53% in the second quarter, 66.28% in the third quarter, and 58.29% in the fourth quarter. Based on the TLS results, this indicator is in the yellow category in the first quarter and third quarter, as well as the red category in the second quarter and fourth quarter. The lowest score occurred in the second quarter, while in the third quarter there was an improvement even though it had not reached the set target. The target time for retrieving archives set by the company is 0.13 hours or 13 minutes per archive box. Based on actual data, the average time to retrieve archives ranges from 0.25 to 0.29 hours per archive box or about 15–17 minutes. The difference between the target and the realization causes this indicator to not reach the set target. These results show that the process of searching and retrieving archive boxes still takes a little longer than the target set by the company. This condition has the potential to affect the speed of archive services to users, especially when the number of archive requests increases. Therefore, improvements in the search and

archival retrieval process are still needed to support the achievement of the service time target that has been set.

2. The *lead time* (T2) order indicator obtained an achievement value of 63.29% in the first quarter, 57.53% in the second quarter, 66.28% in the third quarter, and 58.92% in the fourth quarter. The lowest realization values were in red in the second quarter and fourth quarter. Based on actual data, the average order lead time is in the range of 86 hours, while the target set by the company is 72 hours. Thus, users receive an average archive within about 3.5 to 3.7 days from the time the request is submitted, longer than the company's target of 3 days. This condition shows that the process of fulfilling archive requests still takes longer than the set standards so that users do not always receive archives according to the expected service time. When compared to *the order picking time* (T1) indicator, the low order lead time achievement shows that the service time is not only influenced by the process of searching and retrieving archives, but also influenced by other stages after the archive is found, such as the verification process, administration, and submission of archives to users. This condition is also seen in the *customer satisfaction indicator* (Q4), where the value of user satisfaction tends to decrease in quarters that have lower order lead time achievements. Therefore, improvements to this indicator are important because they are directly related to the speed of service and user satisfaction with archive warehouse services.

Based on the results of the performance measurement of PT X's inactive archive warehouse described earlier, it is known that most of the indicators have reached the set targets and are in the green category. However, there are still several indicators that are in the yellow and red categories, especially in the *Time*. This condition shows that even though the quality of service, accuracy of archive management, and control of operational costs have gone well, the aspect of archive service speed still needs to be considered. Indicator *order picking time* (T1) and *order lead time* (T2) is an indicator that needs to be prioritized to be evaluated because it consistently shows achievements below the target. These two indicators are directly related to the process of searching, retrieving, and providing archives to users so that they affect the timeliness of the overall service. Further analysis is needed to identify the factors that cause the performance targets on both indicators to not be achieved. The results of the analysis are expected to be the basis for the preparation of improvement proposals to improve the performance of PT X's inactive archive warehouse in the coming period.

Recommendations for Improvement in the Warehousing Process of PT X's Inactive Archives

Based on the results of the performance measurement of PT X's inactive archive warehouse using the WKPI method, it is known that most of the indicators have reached the green and yellow categories. However, there are still two indicators that obtain the red category based on TLS, namely *order picking time* (T1) and *order lead time* (T2). This condition shows that there is still *Gap* between the target and the realization so that there is a need for improvement to optimize the warehousing process. As a basis for the preparation of improvement recommendations, it is carried out *root cause analysis* (RCA) use *fishbone diagram* against both indicators that have a red category. This analysis aims to identify the factors that cause low performance achievements so that the proposed improvements are in

accordance with operational conditions. Identification *root cause* It is carried out based on the results of performance measurement and confirmed through discussions with personnel involved in warehouse operations. Furthermore, the results of the identification *root cause* It is used as a basis for the preparation of improvement recommendations which are expected to increase the speed of archive services and support the achievement of overall warehouse performance targets.

Root Cause Analysis Indikator Order Picking Time (T1)

To identify the factors that cause the low achievement of the indicator *order picking time* (T1), identification was carried out *root cause* based on the results of performance measurement and confirmed through discussions with personnel involved in the operation of PT X's inactive archive warehouse. *fishbone diagram* which refers to the category of causes commonly used in operational analysis, namely *man*, *method*, *machine*, *material*, and *environment*. Causative factors included in *fishbone diagram* It was selected based on its suitability with the operational conditions of the archive warehouse and its relationship with the results of performance measurements. Low performance *order picking time* (T1) is influenced by factors *method* and *environment*. These two factors are related to the archive box search process and the storage condition of archive boxes that develop as the number of stored increases. From the aspect *method*, the process of finding the location of the archive box is still carried out manually by referring to the available storage location information. To take the archive box according to the order, the officer needs to match the information on the location of the archive box with the storage position on the shelf before the retrieval process is carried out. This process causes the search to take longer than if it is supported by a search system that is already digitally integrated. This is one of the factors that affect low performance *order picking time* Because the time it takes to find an archive affects the total time of retrieving the archive.

In addition, the *environment* also affects performance *order picking time*. Based on the measurement data, the number of archives stored increased during the research period as indicated by the increase in value *inventory utilization*. The increase in the number of archives causes the storage area that officers must search to become wider. This condition has the potential to increase the time needed to find the location of the requested archive box, especially when the archive box is stored in a location relatively far from the service area or archive collection area.

Based on the results of the analysis, it can be concluded that the low performance of *order picking time* Influenced by the process of searching archive boxes that are still carried out manually and the increasing area of storage due to the increase in the number of archive boxes managed. Therefore, improvements need to be focused on the archive search process and storage location management so that the time needed to find and retrieve archive boxes can be further reduced according to the target.

Root Cause Analysis Indikator Order Lead Time (T2)

To identify the factors that cause the low achievement of *the order lead time* (T2) indicator, root *cause identification* was carried out based on the results of performance measurement and confirmed through discussions with personnel involved in the operation of

PT X's inactive archive warehouse. Low performance *order lead time* (T2) is influenced by factors *Method*, *machine*, and *environment*. These three factors are related to the archive ordering process, archive distribution, and operational conditions that affect the time to hand over archives to users. From the aspect *Method*, the process of ordering archive boxes is still done manually through *E-mail* Where every incoming request needs to be verified first before being further processed by the warehouse officer. This stage causes the time needed from the time the request is submitted until the archive begins to be processed to be longer. This affects the achievement of *order lead time* Because the service time is not only determined by the process of taking records, but also by the administrative process that precedes it.

From the aspect *machine*, the means of transportation used for archive distribution are still limited. Archive distribution is only supported by one operational fleet that is used to meet various archive service needs. This condition can cause waiting times when there are several requests that must be served in adjacent periods so that the process of sending archives to users becomes longer. Meanwhile, from the *environment*, the location of the archive box user spread over different areas causes the distance and delivery time to vary. The farther away the destination location is, the more time it will take to distribute the archive to the user. This condition also affects the achievement *order lead time* Because the distribution time is part of the overall service time from the request submitted until the archive is received by the user. Based on the results of the analysis, it can be concluded that the low performance of *order lead time* Influenced by the archive ordering process that is still carried out manually, the limitation of archive distribution transportation facilities, and the variation in the distance to the destination of the archive.

Recommended Improvements

Based on results *root cause analysis* Against the Indicator *order picking time* (T1) and *order lead time* (T2), several factors were obtained that caused the low performance achievement of PT X's inactive archive warehouse. *E-mail*, limited distribution facilities, and variations in the location of the destination of the archive delivery. Therefore, several improvement recommendations are needed that can support improving the efficiency of the archive warehouse operational process and accelerating the time of archive service to users.

Table 2. Recommendations for Improvement Based on RCA Results

No	Indicator	*Root Cause*	Proposed Improvements
1	*Order picking time* (T1)	The process of finding the location of the archive is still carried out manually	Implementation of RFID technology in archive boxes to speed up the process of identification and tracing of archives
2	*Order picking time* (T1)	The archive search area is getting wider due to the increase in the number of archives	Evaluation and optimization of the arrangement of archive storage locations to facilitate the process of searching and retrieving archives

No	Indicator	*Root Cause*	Proposed Improvements
3	*Order lead time* (T2)	The process of ordering archive boxes is still done manually via *email*	Development of a *web-based archive booking system* that is integrated with the verification and monitoring process of archive request status
4	*Order lead time* (T2)	Limited archive box transportation facilities	Optimizing the utilization of distribution fleets and evaluating fleet needs based on the volume of archive requests
5	*Order lead time* (T2)	The distance and destination of delivery of the archive box vary	Optimization of archive distribution routes based on the location of the delivery destination to reduce delivery time

Table 2 shows the improvement recommendations compiled based on the root cause that has been identified at the *root cause analysis* stage. The recommendation is to address factors that affect the achievement of T1 and T2 indicators. The *order picking time* (T1) indicator is included in the red category based on TLS results. The low realization of this indicator shows that the time needed to find and retrieve archive boxes is still longer than the target set by the company. Based on the results of RCA, this condition is influenced by the process of searching for archive locations which is still carried out manually and the wider search area due to the increase in the number of archives stored in the warehouse. The increase in the number of archives causes officers to search a wider storage area so that the search and retrieval time for archives becomes longer.

From these problems, recommendations for improvements that can be made are the application of *Radio Frequency Identification* (RFID) technology in archive boxes and optimizing the management of archive storage locations. RFID is a radio wave-based identification technology that is used to read and store data automatically through *tags* attached to an object and can be read using a special device without the need for direct contact in *real-time tracking*, so it is widely used to minimize the movement of goods in logistics and warehousing activities (Ahsan, Shah, & Kingston, 2010).

For the implementation recommendation, each archive box is given *Tags* RFID connected with *database* archival storage. When there is a request for an archive, officers can access the information on the location of the required archive box through the system and identify it using RFID *reader*. Thus, the process of searching and retrieving archives can be done faster than manual methods because officers do not need to visually match the identities of archive boxes one by one. In addition to supporting the acceleration of the archive search process, the application of RFID can also improve the ability to track the position and status of archive boxes during the warehouse operational process. In addition to the implementation of RFID, improvements can also be made through optimizing the management of archive storage locations. A more structured arrangement of storage locations will make it easier for officers to find the required archive boxes so that the time for searching and retrieving archives can be reduced. With these two improvements, the time required in the process of searching and

retrieving archives is expected to be reduced so that the realization of indicators *order picking time* (T1) can increase.

Indicator *order lead time* (T2) is included in the red category based on TLS results. The low realization of this indicator shows that the time required from the request for the archive box is submitted until the archive is received by the user is still longer than the target set by the company. Based on the results of RCA, these conditions are influenced by the process of ordering archive boxes which are still carried out manually via email, limited archive transportation facilities, and variations in distance and destination for archival delivery. This condition causes the time for archive services to be longer, both at the administration stage and the distribution of archives to users.

From these problems, the recommendation for improvement that can be done is the development of an archive-based ordering system *Web*, optimization of archive distribution facilities, and optimization of archive delivery routes. Archive-based ordering system *Web* recommended to replace the archive request process through *E-mail* which has been used. Through this system, the process of submitting archive requests, verification, approval, and monitoring the status of requests can be carried out in an integrated manner in one *platform*. In addition, the entire history of archive requests can be documented automatically, making it easier to monitor and control archive services.

For implementation recommendations, users can submit archive box requests through a web-based system connected to the archive database. Once the request is submitted, the system will forward a notification to the relevant officer for verification and follow-up process. The status of archive requests can also be monitored in *real time*. With this system, the time needed at the administration and verification stages is expected to be reduced so that the archive service process becomes faster.

In addition to the development of a web-based ordering system, improvements can also be made through optimizing archive distribution facilities and managing delivery routes. More planned fleet usage arrangements can help increase the speed of archive distribution, while more optimal delivery route planning can reduce distribution travel time to user locations. With these improvements, the overall archive service time is expected to be reduced so that the realization of *the order lead time* (T2) indicator can increase.

The implementation of these improvement recommendations requires cost support for the development of support systems. However, the improvements made are expected to help speed up the process of searching, ordering, and distributing archives so that archive warehouse operational activities can run more optimally. In addition, the use of digital technology can also support more structured archive management and facilitate the process of monitoring and tracking archives.

Theoritical and Managerial Implications

This study contributes to the literature by showing that the Warehouse Key Performance Indicators (WKPI) model can be applied to an inactive archive warehouse, a type of warehouse that has received limited attention in previous studies. The study also extends the WKPI framework by selecting indicators that fit the warehouse characteristics and adding a new indicator, retention disposition timeliness, to better measure archive management performance. In addition, combining the Analytical Hierarchy Process (AHP), the Snorm De Boer scoring

system, and the Traffic Light System (TLS) provides a practical framework for prioritizing and evaluating warehouse performance. For PT X, the proposed framework addresses the absence of a structured warehouse performance measurement system and helps management monitor performance and identify areas that need improvement. The results show that order picking time and order lead time are the main performance issues. To improve these indicators, the study proposes the implementation of RFID technology and a web-based archive ordering system to increase operational efficiency and support continuous performance improvement.

CONCLUSION

Based on the results of the study, it can be concluded that the measurement of the performance of PT X's inactive archive warehouse using the Warehouse Key Performance Indicators (WKPI), Analytical Hierarchy Process (AHP), Snorm De Boer Scoring System, and Traffic Light System (TLS) has succeeded in producing a measurement system design that is in accordance with the operational characteristics of the inactive archive warehouse. Of the 41 WKPI indicators, 9 relevant indicators were obtained and 1 additional indicator, namely retention disposition timeliness, to accommodate the needs of archive management. The weighting results show that the quality dimension has the highest priority, followed by time, productivity, and cost. Performance measurement during 2024 resulted in a good value in each quarter, namely 85.89% (Quarter I), 83.64% (Quarter II), 87.12% (Quarter III), and 86.18% (Quarter IV). However, the order picking time and lead time order indicators are still in the red category, so they require special attention. The results of the Root Cause Analysis (RCA) show that the problem is caused by the manual archive search process, the absence of archive identification and tracking technology, an ordering system that still uses email, limited distribution facilities, and distance factors and traffic conditions. Therefore, the study recommends the application of RFID technology, the development of a web-based archive ordering system, and distribution optimization through fleet scheduling and management to support the implementation of the Digital Supply Chain concept.

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