
Logistics Management Practices and Supply Chain Performance of Vaccines in Public Hospitals in Lamu County

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Athman Haji Kale¹ and Peter Kamoni²

Abstract:

Purpose: The primary objective of this study was to investigate the influence of logistics management practices (LMP) on the performance of the supply chain of vaccines in healthcare facilities across Lamu County. Specific research objectives included assessing the effects of cold chain technology, inventory management, distribution systems, and technical capacity on supply chain performance.

Material/methods: A descriptive survey design was adopted for the study. The population comprised all 32 public health facilities in Lamu County. The units of analysis included facility managers, procurement officers, and vaccine officers, totaling 96 respondents. Data collection was conducted via the distribution of 96 questionnaires, employing a census technique to ensure all relevant respondents were covered.

Findings: The study revealed that cold chain technology and distribution systems most significantly impact vaccine supply chain performance in Lamu County. Inventory management and technical capacity were less influential, despite inventory management having the highest mean score.

Conclusion: The study concludes that adopting logistics management practices is crucial for enhancing the vaccine supply chain in Lamu County. Cold chain technology and distribution systems were particularly effective, suggesting targeted investment in these areas for improved performance.

Value: This research augments existing literature by empirically investigating the logistics management practices influencing vaccine supply chain performance in a specific regional context—Lamu County. It provides actionable policy recommendations, thus serving as a guide for governmental decision-making and workforce training in healthcare logistics.

Keywords: Logistics Management Practices, Lamu County, Inventory Management, Distribution System, Supply Chain Performance, Technical Capacity, Cold Chain Technology

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¹ School of Business and Economics, Mount Kenya University-Thika; athmanhaji@gmail.com

² School of Business and Economics, Mount Kenya University-Thika

1. Introduction

Logistics management practices plays a big role when it comes to the performance of supply chain management in the current global dynamic atmosphere. The core aspect of the diversity in the logistics system ensures that the delightful stream of inputs is possible through the supply chain management in the organization (Gunasekaran & Ngail, 2018). Both private and public health care facilities recognize that supply chain management is essential to create and maintain economic advantage for outputs in a congested marketplace (Mwinzi, 2018). Logistics management practices are important in the Management of Supply Chain and need to be incorporated with other supply chains like customer services, storage, distributed systems, inventory control, cold chain technology, technical capacity, order process management as well as reduction of cost in supply chain management (Harrison & Hoek, 2019).

Health sector forms the economic evolution engine recognized as the major tradable segment in the developing economies like Kenya (Cooper, 2017). Logistics is part of the retail management that is thorny for the scholars and researchers when focusing on the last mile problem in the context business management (Maryam, 2019). About 8% of the vaccines taken to Lamu county lose their value annually due to the inefficient execution of critical day-to-day processes in terms of inventory, distribution, cold chain technology and technical capacity (Branch, 2019). This is caused by the distance and insecurity experienced in Lamu over the recent years. The speed is essential hence the time for the distribution of the products to the end user is essential. The logistics manager should ensure that both inputs and outputs get their point of destination for the purpose of satisfying customer needs.

The current environment calls for hospitals to integrate Logistics Management Practices into the purposes to remain competitive and ensuring that logistical cost and supply chain management is taken care of well (Branch, 2019). While previous studies; Mwinzi, (2018), Timnah (2017) and Gunasekara & Ngail (2018) explain various aspects of how logistics practices and supply chain management are related but fail to explain the association between logistics practices and supply chain of vaccines. However, in areas where logistics management practices are fully adopted, performance is guaranteed.

There are limited studies on how supply chain performance of vaccines is influenced by management logistics practices in Kenya and more specifically in Lamu county. A knowledge gap has been created and need to be filled. From the problem statement, the study intended to fill the research gap. This study answers the question: What is the influence of logistics management practices on the supply chain performance of vaccines in Lamu County public health care centres?

1.1. Specific Objectives

- i. To establish the influence of cold chain technology on vaccine supply chain performance in public hospitals in Lamu County.
- ii. To determine the influence of inventory management on vaccine supply chain performance in public hospitals in Lamu County.
- iii. To find out the influence of distribution systems on the performance of vaccine supply chain in public hospitals in Lamu County.

- iv. To assess the influence of technical capacity on performance of vaccine supply chain within the public hospitals in Lamu County.

2. Theoretical and Literature Review

2.1. Theoretical Framework

This study has worked on two theories that relates to the supply of vaccines in public health facilities in Lamu County. The theories are; Agency Theory and Resource Based Theory. Agency theory was propounded by Jensen, (1976) as quoted in (Njuguna M. W., 2020). It explains the relationship between the agent and principal where the acts on delegated powers from the principal where the agent acts on the account of the principal and conduct operations with a third party. This theory helps in understanding the conditions under which supply chain team may attempt to abuse other members. Agency theory also gives a guidance on the investigation of the effectiveness of supply chain performance and how it can be reduced to minimize cost. It was promoted with seminal work of Max Weber (Njuguna, 2020) which had the concerns of the conflict between masters of politics and the officians of state. This theory is relevant in this study since supply chain management involves two parties (buyer and the supplier) where the supplier is the agent and the buyer is the principal. The agent is supposed to undertake the contracted activities within a specified period based on defined time lines. This theory is as well important to find out whether suppliers who carry out activities on behalf of public hospitals and the government of Kenya obey the defined timelines and all the provisions of the contract on behalf of the principal who is the Kenyan taxpayer (Charlene, 2019).

This theory was propounded by Wernerfelt, (1984) as quoted in (Njambi, 2018) as one the management theories widely referenced because of its management practices. It emphasized on the inner capability and weaknesses of institutional resources and shows the control of procedures and how resources are distributed and arranged for execution aims of various plans (Mwinzi, 2018). According to Njambi, (2018) resource based theory thus brings about the existence of convinced focus on resources under the organization and different properties that make clear to company supply chain performance that would be long term development.

According to Barney (2003) in (Mwinzi, 2018), for the successful implementation of logistics management practices, resources should be strategic. This is because the viewpoint of resources based on a modern outlook includes the organization's elements like structures within the supply chain. They try to harmonize information disseminated among them to assure the key stakeholders in the organization management to fully ensure that proper logistics management practices in implemented. For the organization to have the best effective practices, they are dependent of the use and manipulation of the current resources to an degree of firms having pools of resources that are under-utilized while creating particular firm oriented and unique opportunities for utilization (Mentzer et al, 2019). This view point is fully applicable in this research as it views the proper use of resources (vaccines) that public hospitals has for the purpose of improving distribution of vaccines from the point of production to customers' point of collection.

2.2. Logistic Management Practices and Supply Chain Performance

The operations of vaccines are the efficient incorporation of the raw materials from the original point of production to the people being vaccinated (Oketch, 2019). The significance brought about by the logistics management practices has been increasing all along and noted by both big and small firms involved in manufacturing hence the practices are important to any public hospital dealing with distribution of vaccines. This is because they need to ensure that the final products are delivered to the end users through logistics function by promotion of supply chain performance by bringing about reducing cost, efficiency and effectiveness (Kiplagat, 2020).

Adoption of cold chain technology in the logistics of vaccines has provided easier distribution systems leading to improved accuracy in delivery and tracking ability (Bishara, 2019). Thus, a good coordination among the supply chain components would take a significance of bettering the distribution systems that provide reduced operations cost, improved logistics efficiency and promotion of supply chain performance on organizations (Timnah, 2017).

The primary reason why firms have been adopting these practices is to manage the cost and competitiveness in the supply chain that increase the profitability and sales in the long run (Samuel, 2016). Thus, the organizations should emphasis taking up logistics management to reduce cost leading to the influence of the supply chain performance positively. When the order is communicated and administered on time, the better administration for the arrangement of distribution and activities of stock by meeting the required consumer satisfaction level (Capacino, 2019).

3. Material and methods

Descriptive survey was the method adopted in this study because of it is suitability to collect data and answer the research questions (Kothari, 2004). all the 32 public health facilities in Lamu county were the target population of the study. These facilities were the units of analysis for the study. However, the unit of observation were the 96 respondents who comprised of 32 facility managers, 32 procurement officers and 32 vaccine managers in each public health facility. Therefore, the study targeted 96 respondents (Department of Health, 2023). The census survey helped in determining the sample size. The researcher chose questionnaire as the instrument of data collection in this study which was well-structured questionnaire and tested prior to the research for the purpose of ensuring that the study results were accurate.. The questionnaire reliability was achieved by using Cronbach's Alpha

3.1. Data Analysis

Multiple regression was used to predict values of dependent variables. The suitability of the multiple regression model was analyzed using determination of coefficient R square while real data points were approximated using predictions. The regression was considered to perfectly fit in the data where the R square is equal to 1. Multiple regression model suitability was tested using F-test in the ANOVA table.

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \epsilon$ Where:

Whereas, X is the set of logistics management practices measured against the performance of supply chain vaccines at the public health applications in Lamu County. Therefore:

X₁: Cold Chain Technology

X₂: Inventory Management

X₃: Distributed Systems

X₄: Technical Capacity

4. Findings and Discussion

4.1. Descriptive Analysis

Cold chain technology, inventory management, distribution systems and the technical capacity were identified as the independent variables while supply chain performance of vaccines was the dependent variable of this study. In order to analyze the data from the respondents, descriptive statistics like mean and standard deviations were used. Statistical Package for Social Sciences (SPSS) was used to define and compare variables as well as obtaining descriptive statistics.

4.1.1. Cold Chain Technology

The study sought to establish the influence of cold chain technology on the supply chain performance of vaccines. The results were obtained from the respondents as follows: functional storage equipment (mean 2.158, SD 1.53445), measures in place to ensure vaccines are in good condition (mean 2.0105, SD 1.3329), enough storage space (mean 1.9684, SD 1.3872), storage practices in line with cold chain technology (Mean 2.2316, SD 1.5050). The findings are presented in the table 1 below:

Table 1: Cold Chain Technology

Cold Chain Technology	Mean	Std. Deviation
Functional storage equipment	2.158	1.5345
Measures in place to ensure vaccines are in good condition	2.0105	1.3329
Enough storage space	1.9684	1.3873
Storage practices in line with cold chain technology	2.2316	1.5050

Source: SPSS output (2023)

Table 1 above showed that all the means of the reported variables were below 3 which meant that the respondents did not agree with the items raised. It was clear that cold chain technology has not been utilized in Lamu County. A study conducted by Bishara, (2019) found out that there are some barriers that pertains to the adoption of cold chain technology like poor equipment, storage space and lack of will from the management. Internal issues were found to be the biggest determinant to the success of utilizing cold chain technology. While vaccines can only be distributed by Kenya Medical Supplies Agency (KEMSA), maintaining the right quality has been a nightmare because of the transport issues, security, corruption and the tedious bureaucracies of the government.

4.1.2. Inventory Management

The second objective sought to determine the influence of inventory management on the performance supply chain of vaccines in Lamu County health care facilities. The respondents were given the opportunity to describe the extent of how this logistical management practice influence supply chain performance and the findings are as indicated. Management makes sure of enough storage facilities (mean 3.4632, SD 1.2099), handling equipment of vaccines are available (mean 3.3474, SD 1.1829), there is availability of inventory management systems (mean 3.5684, SD 1.1638), and inventory practices are satisfactory (mean 3.5580, SD 1.2439). The results above show that inventory management is low as far as the supply chain performance of vaccines in Lamu County is concerned. However, as indicated in Table 2 below, the means of the items are above 3 which means that the respondents generally agreed with the items.

Table 2: Descriptive Statistics on Inventory Management

Inventory Management	Mean	Std. Deviation
Management makes sure of enough storage facilities	3.4632	1.2099
Handling equipment of vaccines are available	3.3474	1.1829
There is availability of inventory management systems	3.5684	1.1638
Inventory practices are satisfactory	3.5580	1.2439

Source: SPSS output (2023)

The supply chain performance is influenced by how the inventory management is carried out. For the inventory management to be effective, the products should be available when needed which is essential for an efficient supply chain performance (Cooper, 2017). In contrary, poor inventory management may result into stock outs, delays, exaggerated costs and therefore negatively affecting the entire supply chain. In the presence of adequate storage facilities, proper handling of vaccines and implementing inventory practices such as management software and adoption of lean inventory practices helps in improving and enhancing the overall performance of the vaccine supply chain. An effective inventory management has benefits like cost savings which minimize excess inventories, reduction of inventory holding cost like handling and storage costs. The accuracy of demand forecasting as well as proper inventory planning helps the businesses to avoid stock outs and cost reduction of rush orders (Emmanuel U., 2021). The other benefit of inventory management is that there is increased efficiency in the supply chain operations. Further, the effective inventory management helps the firm to minimize the need for manual inventory tracking and data entry, freeing up time as well as resources to be used in other company departments. The last benefit of using inventory management is that it leads to improved customer service because the products are available in stock and customer needs are met. The organizations that have accurate demand forecasting avoids stock outs and therefore increase customer satisfaction and increased sales (Lee, 2017). These previous studies are in relation to the inventory management of vaccines in Lamu county were in agreement that the items identified were practices although their opinions varied as shown in the standard deviation results.

4.1.3. Distribution Systems

The third objective examined the influence of distribution systems on the performance of supply chain of vaccines among health care centres in Lamu County. When the respondents were asked about this logistic management practice, the following findings emerged: Execution of the movement of vaccines (mean 2.1789, SD 1.6176), optimization of the daily operations of fleet systems to manage distribution (mean 4.3579, SD 1.2793), use of specialized vehicles (mean 4.8002, SD 0.6620) and planning and monitoring of the transport systems (mean 4.6843, SD 0.7755). All the items with the exception of item 1 had means above 4 where the respondents totally disagreed with the execution of the movement of vaccines. The three items with means above 4 meant that the respondents overwhelmingly agreed with the statements. The findings from the respondents shows that the distribution systems are averagely used in the health care centres in Lamu County as shown in Table 3 below.

Table 3: Descriptive Statistics on Distribution Systems

Distribution Systems	Mean	Std. Deviation
Execution of the movement of vaccines	2.1789	1.6176
Daily operations of fleet systems to manage distribution	4.3579	1.2793
Use of specialized vehicles	4.8002	0.6620
Planning and monitoring of the transport systems	4.6843	0.7755

Source: SPSS output (2023)

From the data findings above, it is clear that distribution systems have an important impact on the supply chain performance of vaccines. For the health care centres in Lamu county to be efficient and effective, there should be a good distribution management process that would convey vaccines from the suppliers (KEMSA) to the final consumers (patients). Successful vaccination programs are built on working end-to-end supply chain systems. These systems brings about effective storage of vaccines, distribution, handling, management and rigorous control in the cold chain technology and efficient logistics management systems (Timnah, 2017). The main objective is to ensure there is availability of vaccines from the manufacturers to the delivery levels so that the people to be vaccinated do not miss the opportunity because of unavailable vaccines.

Success stories of vaccination programmes in Kenya has been reported but there is an increasing pressure to effectively manage the need of new vaccines introduction in remote areas like Lamu where there are transport issues (Gunaseakaran and Ngail, 2018). Distribution systems ensures that vaccines are available, in the right quantity and quality. Promotion of integration with other supply chains should be key and investing in effective systems that manages, treats and disposes the vaccine wastes for reducing environmental degradation.

4.1.4. Technical Capacity

The fourth and last objective sought to determine the influence of technical capacity on the influence of supply chain performance of vaccines among health care centres in Lamu County. The respondents were expected to respond to various items on the level of agreements and these were the outcomes: Employees are specifically trained to handle cold chain vaccines (mean 4.2000, SD 1.1904), there is enough equipment to handle increasing demand (mean 3.3474, SD 1.3973), there are quality checks of ensuring compliance with cold chain technology (mean 3.6001, SD 1.3079) and there is constant power supply for cold chain equipment (mean 3.8737, SD 1.1508). The findings above show that there is technical capacity among the health care centres in Lamu County. As seen in Table 4 below, all the items had a mean greater than 3 indicating that the respondents averagely agreed on the statements posed to them.

Table 4: Descriptive Statistics on Technical Capacity

Technical Capacity	Mean	Std. Deviation
Employees are trained to handle cold chain vaccines	4.2000	1.1904
There is enough equipment to handle increasing demand	3.3474	1.3973
There are quality checks of ensuring compliance	3.6001	1.3079
There is constant power supply for cold chain equipment	3.8737	1.1508

Source: SPSS output (2023)

Though the technical capacity items in the construct were low, the results were consistency with the literature from the previous studies. Emmanuel Habumugisha, (2022) did a study in the Rwanda Journal of Medicine and Health Sciences. He found out that the interest of various governments has been on how to develop new vaccines for emerging illness and gauging their effect on the human body. However, Mwinzi (2018) in his study found out that the most effective product can only have impact by getting to the final consumer. Cooper (2017) found out that the supply chain of vaccines is a complex process that involves various equipment, distribution system, location involved in getting vaccines (bearing in mind some are perishable and sensitive to temperature) from the producer to the final consumer. Therefore, the technical capacity of the people involved in the supply chain is very important as there are many issues to be considered before the vaccine gets to the market to help in designing vaccines that matches the needs of the end user.

Assi (2021) did the study on influenza vaccination policy affecting vaccine logistics. It was found that the development of clinical and vaccines testing involve many decisions which are connected with the vaccine supply chains. For instance, when HERMES modelling work in Thailand was established and found out that the delivery of vaccines to selected population affected not only influenza vaccine but other vaccines as well. Cervantes-Apolinar, (2021) in his Arch Medical research noted that it was important for the technical capacity of the vaccine clinical trialists to be involved since choosing a general vaccination rather than a more focused higher risk population for the seasonal influenza vaccine like health workers, children, old people and pregnant women would lead to more volumes of vaccines during flue vaccination season leading to impediment of the flow of the program. Clinical trialists are involved in making decisions like identifying the population to be targeted, consider the system-wide effects and the

potential need for supply chain strengthening in order to accommodate such targets (Cooper, 2017).

The technical capacity of the vaccine package designers is equally important as the package of the vaccine greatly affect supply chain. This is evidenced when in 2020 the preliminary packaging for COVID-19 vaccines was too large for supply chains in Italy and Latin America to handle (Cervantes-Apolinar, 2021). Pfizer and Johnson and Johnson's Rotarix worked on filling greater cold chain volumes than other routine vaccines, thereby creating bottlenecks that ultimately disrupted the flow of all other vaccines due the pandemic.

WHO (2020) in the study to develop a vision of immunizing supply systems in 2020: landscape analysis summaries noted that healthcare workers have the mandate of adapting the logistics management practice because of the accessibility of vaccines. The issues of supply chain can bring about stock outs that would eventually push the healthcare workers to turn people away without vaccination (World Health Organization., 2020).

4.2. Logistics Management Practices and Supply Chain Management

The study further sought to find out the relationship between logistics management practices and supply chain performance of vaccines among public healthcare centres in Lamu County. Regression analysis was used to find out the relationship between the inventory management, distribution systems, cold chain technology and technical capacity and the dependent variable to illustrate the expected relationship between the two variables. The findings are as indicated in Table 5 below.

Table 5: Regression Model Summary

Model	R	R Square	Adjusted R Square	Std Error of the Estimate
1	.729 ^a	.531	.473	.36393

Source: SPSS output (2023)

a. Predictors: (Constant), inventory management, distribution systems, cold chain technology and technical capacity.

R-square from the regression model above indicated the variation in the dependent variable explained by the independent variables under study. The R-square in this study was 0.531, an indication that all the independent variables combined are 53.1% of the dependent variable while the remaining 49.1% variation is explained by other factors not included in the model. Therefore, the conclusion of this study is that there are more factors that could be influencing the supply chain performance of vaccines in Lamu county other than the ones in the study.

The Analysis of Variance (ANOVA) was carried out and the findings are as indicated in Table 6 below.

Table 6: Analysis of Variance (ANOVA)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	6.016	5	1.185	9.070	.000 ^b
Residual	5.278	41	128		
Total	11.294	46			

Source: SPSS output (2023)

- a. Supply Chain Performance of Vaccines (dependent variables)
- b. Cold chain technology, inventory management, distribution systems and technical capacity (independent variables or the constant).

It was out of the regression model that the ANOVA was carried out and the findings are as shown in Table 6 above. The F value was at 9.070 indicating that the model can be used to predict how the independent variables influence the dependent variable. The results further in the ANOVA shows that the overall model was significant at 95% confidence level.

The study further sought to find the specific influence of the study objectives on the supply chain performance of vaccines among healthcare centres in Lamu County. To achieve this, the regression coefficients were used to show how each of the independent variables influence the dependent variable, which was the supply chain performance of vaccines in Lamu County. The table 4.13 below shows the regression analysis.

Table 7: Regression Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients		t	Sig.
	B	Std. Error	Beta			
(Constant)	1.445	0.897			1.611	0.115
Distribution Systems	0.384	0.122	0.447		3.146	0.003
Cold Chain Technology	0.883	0.149	0.890		5.947	0.000
Technical Capacity	0.020	0.096	0.023		0.206	0.838
Inventory Management	0.076	0.096	0.094		0.792	0.533

Source: SPSS output (2023)

The regression coefficient models in Table 7 above illustrates that when all the variables are held constant at 0, the worth of supply chain performance of vaccines would stand at 1.445. In addition to this, distribution systems influenced the supply chain performance of vaccines among healthcare centres in Lamu county at $\beta_1 = .384$ and p-value =.003. Therefore, these figures shows that the increase in the utilization of distribution systems on the supply of vaccines would increase to 0.384 among the healthcare centres in Lamu County. The findings of this study further shows that cold chain technology had a positive influence on the supply chain performance of vaccines among healthcare centres in Lamu County at $\beta_2 = .883$ and p-value =.000. This means that for every unit increase in the use of cold chain technology would lead to the improved supply chain performance of vaccines among health care centres in Lamu County by 0.883 units. However, the findings in this study indicated that the inventory

management and technical capacity had little influence on the supply chain performance of vaccines among healthcare centres in Lamu County. This is because their p-value was 0.533 and 0.838 respectively which is far much bigger than 0.05. However, inventory management had more influence on the supply chain performance of vaccines than technical capacity because their standardized coefficients stood at 0.076 and 0.020 respectively. Thus, the findings show that distribution systems and cold chain technology were the independent variables that proved to be suitable predictors of the supply chain performance of vaccines among healthcare centres in Lamu County. These two variables were followed by the inventory management and lastly the technical capacity.

$$Y = 1.445 + 0.883X_1 + 0.076X_2 + 0.384X_3 + 0.020X_4 + \varepsilon$$

The equation above shows that the explanatory variables holding constant the health care centres in Lamu County would be 1.445 units. The results would be the variables which are lateral and not related to the focus of this study. When all other variables are kept constant, the 0.883 rise in cold chain technology would result to the improved supply chain performance of vaccines. Further, it is found in the model that when all other variables are kept constant, the increased performance of vaccine supply chain would be explained by 0.076 units of the inventory management. In addition to this, when all other factors are held constant, the improvement of supply chain performance of vaccines would have been attributed to the increase in the distribution system of 0.384 units. Finally, there was found to be a significant different when it came to the technical capacity in relation to the supply chain performance of vaccines among health care facilities in Lamu County. There were a mere 0.020 increase in units. The results either shows that technical capacity did not have influence when it came to the supply chain performance of vaccines or this logistic management practice was not taken into consideration in Lamu county health care facilities.

5. Conclusion and Recommendations

The study aimed to explore the influence of logistics management practices on the performance of vaccine supply chains in healthcare centres within Lamu County. The data gathered indicated comprehensive adoption of these practices, with all four variables under study showing positive mean values above three. The regression analysis further substantiated the positive impact of logistics management practices on the vaccine supply chain. A Multiple Determination value of 0.531 revealed that 53.1% of the changes in supply chain performance could be attributed to these practices. Furthermore, the statistical significance was confirmed with a p-value of 0.000, which falls below the 0.05 threshold at a 95% confidence level.

Based on these results, it is recommended that healthcare centres in Lamu County that have not yet fully implemented logistics management practices, particularly in the areas of inventory management and technical capacity, should do so as a matter of priority. Government intervention is essential to enforce standardization of these practices across all healthcare facilities. Additionally, capacity-building initiatives should be organized for procurement teams within these healthcare centres, with facility managers ideally spearheading these training programs to ensure cost-effectiveness and performance enhancement.

In terms of future research, there is a need to investigate the impact of logistics management practices on the supply chains of other pharmaceutical products beyond vaccines. Such studies should also extend their focus to other sectors and evaluate alternative management practices, to provide a comprehensive understanding of how different management practices influence supply chain performance across various sectors.

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