The influence of warehouse management of cold storage business on the efficiency of product control in temperature-controlled warehouse for cold storage

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Abstract

This research aims to 1) study the level of warehouse management of cold storage businesses, 2) study the level of product control efficiency in temperature-controlled warehouses for cold storage businesses, and 3) study the influence of warehouse management of cold storage businesses on product control efficiency in temperature-controlled warehouses for cold storage businesses. The sample group in this research is 150 warehouse employees of cold storage businesses, and stratified random sampling is used, considering the size of the cold storage business, proportionate to the population of large, medium, small, and retail customers. The instrument used is a questionnaire for data collection. The statistics used for data collection include the mean and multiple regression analysis. The research results found that: Warehouse management of cold storage businesses is found to be at the highest level overall, with the top 3 opinions at the highest level, namely, product disbursement, product layout, and product receiving. 2) Product control efficiency in temperature-controlled warehouses for cold storage businesses is found to be at the highest level overall, with the top 3 opinions at the highest level as follows: Focus on providing warehouse services that are continuously worthwhile, fast and accurate, and using great care. To prevent damage to the products when stored in the warehouse and to use automation systems or technology to help manage to save time and labor, resulting in cost reduction and 3) Warehouse management of cold storage businesses in terms of product layout, product disbursement and product movement/transportation influence the efficiency of product control in temperature-controlled warehouses for cold storage businesses and a fairly high level of relationship.

Keywords: Warehouse Management, Product Control, Efficiency, Temperature Controlled Warehouse

1. Introduction

From 2023 to 2025, the rental warehouse business is expected to expand in line with global and Thai economic trends. The recovery of Thailand's tourism sector has boosted consumer demand, benefiting manufacturing and e-commerce businesses, leading to increased investment in rental warehouses. However, competition is intensifying due to expansions by major players, new entrants, and foreign investors, increasing warehouse supply by approximately 1.1–1.3 million square meters annually (5.8% per year), potentially causing oversupply in certain areas

and limiting rental price increases. One key segment is cold storage warehouses, designed to preserve perishable goods such as seafood, dairy products, fresh flowers, meat, fruits, vegetables, and pharmaceuticals. According to research by Krungsri Research (2023), cold storage warehouse revenue is expected to grow slightly due to rising demand for agricultural and processed food storage for both domestic consumption and export. However, increasing supply from new entrants and higher operational costs (electricity and labor) may limit profit margins.

Changing consumer behavior, driven by demand for convenience, hygiene, and safety, has fueled growth in ready-to-eat, chilled, and frozen food markets, boosting demand for cold storage warehouses. Additionally, food processing industries (e.g., seafood, bakery, and dairy) are investing in these facilities to maintain product quality, leading to intensified competition. Technology adoption, such as Automated Storage and Retrieval Systems (ASRS) and Cold Chain Management Systems (CCMS), enhances operational efficiency and real-time inventory tracking. Thailand's chilled and frozen seafood industry remains significant, with exports accounting for 61% of total production in 2022. However, global economic slowdown, inflation, and currency fluctuations have impacted export demand, particularly in key markets like Japan, China, and the U.S. In the first nine months of 2023, seafood exports fell by 10.1%, while meat exports slightly increased by 1.14%.

Given these dynamics, cold storage warehouse operators must enhance warehouse management strategies, workforce skills, and operational efficiency to maintain competitiveness and meet increasing customer expectations. This research focuses on the impact of cold storage warehouse management on inventory control efficiency, aiming to improve best practices and enhance performance in the temperature-controlled logistics sector.

1.1 Research Objective
1) To study the level of warehouse management in the cold storage business and the level of inventory control efficiency in temperature-controlled warehouses for the cold storage business.
2) To study the influence of warehouse management in the cold storage business on the efficiency of inventory control in temperature-controlled warehouses for the cold storage business..

2. Literature Review

Jing Sun Fanwei, Zhag Peicheng Lu, and Janney Yee (2019) studied optimal modeling and opportunity cost analysis for hazardous goods in warehouse operations. The research addresses overload conditions caused by inefficient traditional storage methods and proposes a temporary warehouse positioning system with opportunity cost analysis. A hierarchical optimization model was developed, incorporating warehouse operation characteristics and a quadratic programming model for safety and efficiency. Additionally, a new BP neural network was introduced to optimize forklift routing. The study demonstrates that position-to-temporary-position connections effectively enhance operational efficiency.

Vukasin Paji, Milan Andrejic, and Prasenjit Chatterjee (2024) investigated improvements in cold chain logistics by developing an advanced temperature monitoring framework for transportation and storage. The study analyzes the complexities of managing temperature-sensitive goods, emphasizing real-time temperature tracking via integrated data management

systems. Smart transportation solutions utilizing IoT enhance monitoring reliability. Standardized protocols ensure consistency in temperature management, leading to improved quality control and safety in cold-chain logistics.

Waldhans et al. (2024) explored food temperature control and data exchange in supply chains, focusing on digital applications of time-temperature indicators (TTI). The study examined German companies across production, logistics, and retail to assess temperature tracking and data management. It analyzed three supply chain models (B2C for raw pork sausage, B2B for fish, and B2C e-commerce for mixed products) to evaluate TTI adoption. Findings indicate minimal temperature data exchange among stakeholders, with reliance on visual inspections and expiration labels. TTI integration with app-based reading systems reveals insights into cold-chain disruptions, particularly in B2B logistics. The study highlights the potential of TTI for improving perishable goods management under real-world conditions.

3. Methods

The study population consists of warehouse employees from cold storage businesses, with a total of 193 businesses (Priyanuch Satyapongphakdee, 2023). The sample includes warehouse employees from these cold storage businesses. Using the Krejcie and Morgan (1970, pp. 607-610) formula, the required sample size was calculated to be 129. To enhance the study, an additional 31 samples were included, resulting in a total sample size of 150. The researcher selected 1–2 employees per business and applied stratified random sampling, dividing the sample based on the population proportions described by Priyanuch Satyapongphakdee (2023). The sample distribution was categorized according to business size, ensuring proportional representation.

For statistical data analysis, the researcher employed both descriptive and inferential statistics. Descriptive statistics were used to analyze the personal factors of respondents through frequency and percentage, while cold storage warehouse management and the efficiency of inventory control in temperature-controlled warehouses were analyzed using mean and standard deviation. For inferential statistics, the study tested the hypothesis regarding the influence of cold storage warehouse management on inventory control efficiency in temperature-controlled warehouses using Multiple Regression Analysis. The coefficient of determination (R^2) was applied to measure predictive accuracy, with a significance level set at 0.05. The Enter method was used to select independent variables for regression analysis and formulate a predictive model. Prior to hypothesis testing, the researcher examined the correlation among independent variables to prevent multicollinearity.

4. Results and Discussion

Table 4.7 Mean and standard deviation of data on opinions on warehouse management of cold storage businesses in general

(n = 150)

Warehouse management of cold storage business	$\overline{X}$	S.D.	Results	Rank
Warehouse organization	4.06	0.88	Much	6
Goods receipt	4.24	0.76	Most	3
Product layout	4.30	0.74	Most	2
Product storage/placement	4.24	0.80	Most	4
Product disbursement	4.31	0.80	Most	1
Product movement/transportation	4.16	0.81	Much	5
Include	**4.22**	**0.70**	**Most**	-

From Table 1, opinions on warehouse management of cold storage businesses, overall, it was found that the respondents had the highest overall opinions, with an average of 4.22. When considering each aspect, it was found that the aspects at the highest level were as follows: first, goods disbursement, with an average of 4.31; second, goods layout, with an average of 4.30; goods receipt, with an average of 4.24; goods storage/placement, with an average of 4.24; and then, at a high level, goods movement/transportation, with an average of 4.16; and warehouse organization, with an average of 4.06, respectively.

Opinions on the efficiency of product control in temperature-controlled warehouses for cold storage businesses found that the respondents had the highest overall opinions, with an average of 4.23. When considering each item, it was found that the opinions were at the highest level, as follows: First, focusing on providing warehouse services that are continuously worthwhile, fast, and accurate, with an average of 4.36. Second, using great care to prevent damage to products when stored in the warehouse, with an average of 4.29, and being able to solve problems of product damage more efficiently, with an average of 4.12, respectively.

Table 4.15 Regression Analysis tested the influence of warehouse management in cold storage businesses on the efficiency of product control in temperature-controlled warehouses for cold storage businesses.
    construction sector.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Tolerance	VIF
	B	Std. Error	Beta				
Constant	.503	.177		2.841*	.005		
Warehouse Management (X_1)	.063	.053	.080	1.193	.235	.341	2.930
Cost Savings (X_2)	.080	.071	.087	1.139	.256	.256	3.776

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Tolerance	VIF
	B	Std. Error	Beta				
Warehouse layout (X_3)	.207	.063	.219	3.265*	.001	.344	2.911
Goods storing and positioning (X_4)	.051	.077	.058	.662	.509	.201	4.964
Material requisition and issuance (X_5)	.219	.064	.251	3.424*	.001	.287	3.480
Transfer/ Goods handling (X_6)	.258	.065	.298	3.942*	.000	.270	3.707

* $p < 0.050$

From Table 4.15, the Multiple Linear Regression test found that warehouse management in the cold storage business, after reducing independent variables by selecting those with a significance level (Sig) of 0.05, included the following: Product layout (X3), Goods disbursement (X5), and Product movement/handling (X6). These variables did not present a Multicollinearity problem since the Tolerance values for all three aspects were greater than 0.1, and the VIF values were less than 10. Additionally, the Durbin-Watson value was 2.077, which falls within the acceptable range of 1.5 - 2.5, indicating that the independent variables were not correlated. When examining the correlation coefficient (R Square), the value was found to be 0.778 or 77.80%, indicating a relatively high positive relationship.

The F-test statistic showed a Sig. value of 0.000, which is lower than the significance level of 0.05, suggesting that changes in the three warehouse management variables significantly influenced the efficiency of product control in temperature-controlled warehouses for cold storage businesses. The ranking of these influences is as follows. Product movement/handling (X6) (Beta = .298). Goods disbursement (X5) (Beta = .251). Product layout (X3) (Beta = .219). On the other hand, the warehouse management factors of Goods receipt (X2) (Beta = .087), Warehouse organization (X1) (Beta = .080), and Product storage/placement (X4) (Beta = .058) had Sig. values greater than 0.05, meaning they did not significantly influence the efficiency of product control in temperature-controlled warehouses for cold storage businesses.

Unstandardized Equation: $\hat{Y} = 0.503 + 0.063(X_1) + 0.080(X_2) + 0.207(X_3)* + 0.051(X_4) + 0.219(X_5) + 0.258(X_6)*$

Where: $\cdot \hat{Y}$ = Efficiency of product control in temperature-controlled warehouses for cold storage businesses
   $\cdot X_1$ = Warehouse organization
   $\cdot X_2$ = Goods receipt
   $\cdot X_3$ = Product layout
   $\cdot X_4$ = Product storage/placement
   $\cdot X_5$ = Goods disbursement

· X_6 = Product movement/handling

Standardized Equation: $\hat{Y} = 0.080(X_1) + 0.087(X_2) + 0.219(X_3)^* + 0.058(X_4) + 0.251(X_5) + 0.298(X_6)^*$

Where: $\hat{Y}$ = Efficiency of product control in temperature-controlled warehouses for cold storage businesses
· X_1 = Warehouse organization
· X_2 = Goods receipt
· X_3 = Product layout
· X_4 = Product storage/placement
· X_5 = Goods disbursement
· X_6 = Product movement/handling

5. Conclusion

The majority of respondents were female (74%), aged between 26–35 years (60%), single (72%), held a bachelor's degree (52%), had work experience of five years or less (44%), and worked as warehouse staff (58%). Regarding the first objective, the study found that the overall level of warehouse management in cold storage businesses was at the highest level. The most significant aspects included inventory issuance, warehouse layout, receiving, and storage arrangement, followed by material handling and warehouse organization. The use of warehouse technology, software development, and standardized procedures such as FIFO, Cross Docking, and WMS were key factors in maintaining efficiency. The study also revealed that product receiving processes were well-organized, utilizing technology for documentation and efficient inventory reception. Warehouse layout planning emphasized staff training, movement optimization, and space allocation. Storage arrangement focused on documentation, product verification, and systematic categorization. Inventory issuance procedures were robust, ensuring real-time stock monitoring, controlled access, and clear issuance documentation. Material handling was structured, considering movement efficiency and outsourcing delivery services for flexibility. Regarding the second objective, the effectiveness of inventory control in temperature-controlled warehouses was also at the highest level. The key factors included cost-effective, fast, and accurate warehouse services, stringent precautions to prevent damage, automation to reduce costs, and employee participation in cost-reduction initiatives. Performance tracking and process refinement further enhanced time efficiency and damage prevention. The third objective examined the influence of warehouse management on inventory control efficiency, revealing that warehouse layout (X_3), inventory issuance (X_5), and material handling (X_6) significantly impacted efficiency at a 0.05 significance level, with a relatively high correlation of 77.80%.

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References

Boonmalert., W. (2021). *Teaching materials: Distribution Management and Distribution Center Products.* Nakhon Pathom: College of Logistics and Supply Chain, Suan Sunandha Rajabhat UniversityNakhon Pathom Campus.

CPL Inter Logistics. (2022). *FIFO / LIFO / FEFO Principles of picking and inventory management.*(Online). https://www.cplinter.com/fifo-lifo-fefo/

Khluiprasert., T. (2022). *Increasing the efficiency of warehouse layout: A case study of ABC Company Limited.* Master of Science in Logistics and Supply Chain Management, Faculty of Logistics,Burapha University.

Krejcie, R.V., & D.W. Morgan. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement, 30*(3), 607 – 610.

Kaennaimuang., T. (2021). *Using AFN and ECR analysis methods to improve Warehouse ManagementEfficiency: A Case Study of AAA Company.* Master of Engineering in Engineering Management, Department of Industrial Engineering, Faculty of Engineering, Thammasat University.

Land and Houses Bank Public Company Limited. (2023). *Meat and seafood product business (frozen,processed).* (Online).https://www.lhbank.co.th/getattachment/68ae32ad-0471-4d95-a043-9b4d8bb56919/economic-analysis-Industry-Outlook-2023-Meats-and-

Seafoods Modula. (2024). *Warehouse Management: The Automated Storage Solution MODULA.* (Online).https://modula.asia/th/%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%88%E0%B

PACKHAI FULFILLMENT. (2023). *How important is storage?* (Online). https://packhai.com/product-storage/

Paji., P, Andrejic ., M., & Chatterjee., P. (2024). Enhancing Cold Chain Logistics: AFramework for Advanced Temperature Monitoring in Transportation andStorage. *Mechatronics and Intelligent Transportation System, 3*(1), 16-30.

Praditkul., T. (2022). Basic understanding of inventory control. *Thai Printing Journal. 127*.

Pratumthong., N. (2022). *Increasing Warehouse Management Efficiency for Storage of Automotive Spare Parts Packaging.* Master of Science in Logistics and Supply Chain Management, Faculty of Logistics, Burapha University.

Srisat., B & Nilkaew., B. (1992). *Population Reference Using Scale-based Tools Estimation with Samples.* Journal of Educational Measurement, Srinakharinwirot University, Mahasarakham.

Similan Technology Co., Ltd. (2024). *Storage Strategy in Warehouses.* (Online). https://www.similantechnology.com/news&article/Storage- Strategy.html