Exploring the Factors Influencing Physical Distribution in Cold Chain Logistics in Shah Alam, Malaysia

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Abstract. This study investigates what drives physical distribution performance in Shah Alam's cold-chain logistics by examining four operational factors—product timeline, warehouse management, transportation, and storage conditions. Using a quantitative design, we surveyed 231 employees across cold-chain firms via a five-point Likert instrument. All constructs demonstrated strong internal reliability (Cronbach's α = 0.850–0.936). Correlation analysis showed positive associations among the predictors and physical distribution, and a multiple regression model exhibited good fit (R = 0.837; R^2 = 0.701; Durbin–Watson = 1.95). Results identify warehouse management as the dominant and only robust positive driver of distribution efficiency (β = 1.185, $p < 0.001$). In contrast, product timeline was not significant (β = –0.150, p = 0.077), transportation showed an unexpected negative association (β = –0.222, p = 0.040), and storage conditions were non-significant (β = –0.051, p = 0.649). These findings suggest that isolated improvements in timeline compression, transport capacity, or storage upgrades do not reliably translate into better distribution outcomes unless warehousing processes—inventory accuracy, picking and staging, temperature handling, and coordination—are first optimized. Managerially, firms should prioritize warehouse process discipline, workforce training, and digital enablement (WMS/IoT visibility), then integrate transport scheduling and product-timeline planning to avoid downstream bottlenecks. The study highlights the centrality of warehouse excellence and coordinated, data-driven operations for cold-chain performance, and points to future research on real-time analytics and cross-functional synchronization to enhance last-mile integrity and reduce waste.

Keywords: Cold Chain Logistics, Physical Distribution, Warehouse Management, Transportation, Product Timeline, Storage Conditions

1 Introduction

Cold chain logistics plays a significant role in modern supply chains, particularly for those sectors dealing with perishable materials, such as food, medicine, and chemicals [1]. The central aim of cold chain logistics is to maintain temperature-sensitive products at recommended temperatures throughout the supply chain, right from production to final delivery. This is crucial in ensuring product quality, safety, and minimizing waste,

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which would otherwise accrue significant financial losses to consumers and vendors [2].

Yet cold chain logistics is marred with several problems because of the complexity involved in maintaining strict temperature control while storing and transporting goods. The need for specific equipment such as cold storage, refrigerated vehicles, and containers adds operational complexity [3; 4]. Management of multi-dimensional warehouse networks and adherence to regionspecific regulatory requirements also increases the costs and complexities of operations [5]. These problems can influence product quality, increase costs, and affect customer satisfaction [6; 7].

This study aims at analyzing the determinants of cold chain logistics operations in Shah Alam, one of the key commercial and industrial hubs. Focusing particularly on product timeline management, transport efficiency, warehousing operations, and storage conditions, the study aims at developing actionable principles for driving efficiency, effectiveness, and sustainability in cold chain logistics operations. The findings of the study will improve the distribution of perishable products, both for businesses and consumers within the region [8].

2 Literature review

2.1 Theory of supply chain management (SCM)

Supply Chain Management Theory (SCM) is a system to govern the flow of goods and services, including supply and demand, transportation, warehouse, and inventory [9]. SCM in cold chain logistics determines how key aspects like product schedule, warehouse handling, transportation infrastructure, and storage environments interact to realize successful physical distribution of temperature-dependent products [10]. The theory requires coordination of activities and parties to prevent delays, reduce costs, and maintain product quality and safety. With SCM principles applied, cold chain logistics can deliver perishable goods in a timely manner while maintaining their integrity and reducing wastage, hence overall supply chain effectiveness and efficiency [11; 12].

2.2 Product Timeline and Its Impact on Physical Distribution

Product timeline is crucial in cold chain logistics to preserve quality and prevent spoilage. Kai et al. [13] developed an optimization model using real-time traffic data to reduce delivery delays and maintain freshness. study proposed a model minimizing delivery time, cost, and emissions, supporting both product integrity and green logistics. The COVID-19 pandemic emphasized strict adherence to timelines, especially in vaccine distribution. These studies show that effective timeline management via planning and real-time data is vital for successful cold chain distribution.

2.3 Warehouse Infrastructure and Management Challenges

Warehousing preserves product quality before distribution but is faced with issues of poor temperature control, maintenance, and failure to comply with regulations, leading to product loss [14]. Strategic warehouse location can result in reduced lead times and improved routing [15]. Warehouse service quality affects customer satisfaction and trust [16], and strong coordination is needed to deal with disruptions. Properly maintained warehouses need to be invested in for efficient distribution.

2.4 Transportation Constraints and Innovations

Transportation maintains temperature integrity but suffers from poor infrastructure and coordination, leading to product deterioration [14]. IoT-based temperature monitoring systems can enable real-time corrective actions [10]. Longer routes increase costs and risk temperature excursions [17]. Low investment and infrastructure hinder cold chain transport development in emerging countries [18]. Investment in infrastructure, technology, and collaboration is key to transportation reliability.

2.5 Storage Efficiency and Sustainable Technologies

Storage conditions directly affect product shelf life. Uneven temperature zones cause spoilage even during short storage. Energy-efficient refrigeration reduces costs and environmental impact [19]. Phase change materials improve thermal control and energy use in Malaysian cold chains [20]. Green technologies like renewable energy refrigeration enhance efficiency without compromising quality [21]. Sustainable storage tech is critical for maximizing distribution.

2.6 Integrated Influence on Physical Distribution

Effective cold chain distribution requires integration of timeline management, storage, transportation, and efficiency. Customer satisfaction relies on service quality throughout the chain [22]. Emerging trends include digitalization and real-time monitoring [23]. Upgraded logistics infrastructure improves economic benefits [24]. Collaborative approaches reduce food loss and enhance climate resilience [25]. Efficient cold chain operations provide competitive advantage in e-commerce [26]. Overall, optimizing cold chain distribution demands a holistic approach addressing all key factors simultaneously.

H1: There is a significant positive relationship between product timeline and product's physical distribution.

H2: There is a significant positive relationship between warehouse and product's physical distribution.

H3: There is a significant positive relationship between transportation and product's physical distribution.

H4: There is a significant positive relationship between storage and product's physical distribution

2.7 Research framework

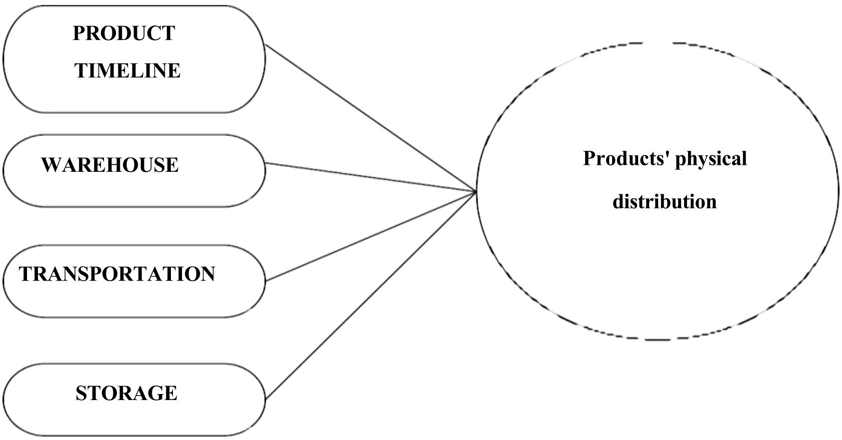

Fig. 1. Conceptual Framework

3 Methodology

This study employed a quantitative research design to investigate factors affecting the physical distribution of cold chain products. Quantitative methods allow for systematic data collection and analysis to explore measurable variables such as product timeline, warehouse management, transportation, and storage conditions, which are critical for maintaining product viability and safety throughout the supply chain [27].

Data were collected from employees and partners of cold chain logistic companies working in Shah Alam, a logistic hub in Malaysia. A non-probability convenience sampling technique was used to select 275 respondents from various industries including manufacturing, logistics, and supply chain management. The sampling method was chosen for its ease and economy of cost to reach participants who have the appropriate expertise and experience in cold chain operations [27]. Sample population was calculated based on Krejcie and Morgan's [28] table to ensure a representative sample.

Primary data were gathered using a standard questionnaire framed in English, the lingua franca of communication in Malaysian logistics firms. The tool had two components: demographics and cold chain logistics variables. Four independent variables product timeline, warehouse management, transport, and storage were measured using six items per variable on a five-point Likert scale that ranged from "Strongly Disagree" to "Strongly Agree." Physical distribution effectiveness was used as the dependent variable and was measured using six modified items. All measurement scales possessed high internal reliability with Cronbach's Alpha ranging from 0.850 to 0.936.

Online questionnaires using Google Forms were distributed with validation to prevent incomplete information and enhance the credibility of the data. Hypothesis testing on hypotheses regarding the impact of independent variables toward physical distribution performance in the cold chain logistics context was conducted.

4 Results

4.1 Demographic Descriptive Analysis

Table 1 presents the demographic profile of the respondents was analyzed using frequencies to summarize the background characteristics of the participants, including age, gender, company, and department. A total of 231 responses were successfully collected, yielding a balanced distribution across various demographic factors, which are critical to understanding the diverse perspectives of participants in this study.

Table 1. Demographic Characteristics

Demographic characteristics	Category	Frequency	Percentage (%)
Age	Below 18	5	2.2
	18-24	153	66.2
	25-30	53	22.9
	Above 30	20	8.7
Gender	Male	120	51.9
	Female	111	48.1
Company	IKEA Supply Malaysia	110	47.6
	DHL integrated warehouse	121	52.4
Department	Logistics/Transportation	35	15.2
	Warehouse/Storage	79	34.2
	Quality Control	78	33.8
	Procurement/Purchasing	39	16.9

The descriptive findings show that among the 231 respondents, 120 (51.9%) were male and 111 (48.1%) were female. Regarding age, the majority of respondents, 153 (66.2%), were between 18 and 24 years old, followed by 53 (22.9%) aged 25 to 30 years, 20 (8.7%) above 30 years, and 5 (2.2%) below 18 years. In terms of company affiliation, 121 respondents (52.4%) worked at DHL Integrated Warehouse, while 110 (47.6%) were from IKEA Supply Malaysia. Concerning department, most respondents worked in Warehouse/Storage (79, 34.2%) and Quality Control (78, 33.8%), followed by Procurement/Purchasing (39, 16.9%) and Logistics/Transportation (35, 15.2%).

4.2 Descriptive analysis

In accordance with Kaur et al [29], descriptive statistics are used to describe population or sample variable correlations for the purposes of data organization. Descriptive statistics are an important first step in the research calculation process and need to be performed before inferential statistical comparisons can be made. Descriptive analysis is a series of brief descriptive coefficients, which represent a data set that can either be representative of the population in general or of a sample. The two types of descriptive analysis are demographic descriptive analysis and descriptive statistics. In demographic descriptive, the frequency value and percentages will define each demographic characteristic. Descriptive statistic. The standard value and mean value will illustrate the division of each variable in Table 2.

Table 2. Descriptive Statistics of Variables

Variable	Mean	SD	Min	Max
Product timeline	23.0173	4.81119	8.00	28.00
Warehouse	23.9481	5.34520	8.00	29.00
Transportation	23.1515	4.51745	8.00	27.00
Storage	23.0433	4.35469	10.00	27.00
Products' Physica Distribution	22.8528	5.90762	8.00	29.00

4.3 Reliability analysis

Cronbach's Alpha is the most common technique to check the internal consistency or reliability of a questionnaire. It indicates whether the items within the survey are consistent in measuring the constructs they were supposed to measure. Cronbach's Alpha was calculated in the current study as the questionnaire was based on a fivelevel Likert scale. Internal consistency reliability coefficients can vary from 0 to 1.00, and values above 0.70 are reported to indicate high reliability.

Table 3. Reliability Analysis

Variables	Number of items	Reliability
Product timeline (PT)	6	0.867
Warehouse (W)	6	0.902
Transportation (T)	6	0.858

Storage (S)	6	0.850
Products' physical Distribution (PD)	6	0.936

Table 3 shows the reliability results for the constructs used in this study. All variables have Cronbach's Alpha values exceeding the 0.70 threshold, indicating that the questionnaire items are highly reliable. Specifically, Product Timeline (PT) has a reliability of 0.867, Warehouse (W) 0.902, Transportation (T) 0.858, Storage (S) 0.850, and Products' Physical Distribution (PD) 0.936, confirming strong internal consistency across all constructs.

4.4 Correlation Analysis

Table 4 presents the correlation matrix among the study variables, along with the number of items and Cronbach's Alpha for each construct. The reliability coefficients for all variables exceed the 0.70 benchmark, indicating satisfactory internal consistency.

Table 4. Correlation Analysis

Variables	Cronbach Alphas	Product Timeline	Ware house	Transportat ion	Storage	Products' Physical Distribution
Product timeline	0.867	1	.857**	.875**	.880**	.626**
Warehouse	0.902	.857**	1	.871**	.882**	.818**
Transportation	0.858	.875**	.871**	1	.931**	.631**
Storage	0.850	.880**	.882**	.931**	1	.655**
Products' Physical Distri-bution	0.936	.626**	.818**	.631**	.655**	1

The correlation coefficients reveal high positive correlations among the variables. Product timeline is strongly correlated with warehouse ($r = 0.857$, $p < 0.01$), transportation ($r = 0.875$, $p < 0.01$), storage ($r = 0.880$, $p < 0.01$), and products' physical distribution ($r = 0.626$, $p < 0.01$). Similarly, warehouse management is highly correlated with transportation ($r = 0.871$, $p < 0.01$), storage ($r = 0.882$, $p < 0.01$), and physical distribution of products ($r = 0.818$, $p < 0.01$). Transport is highly correlated with storage ($r = 0.931$, $p < 0.01$) and physical distribution of products ($r = 0.631$, $p < 0.01$). Storage is positively correlated with physical distribution of products ($r = 0.655$, $p < 0.01$).

These findings demonstrate that all of the independent variables are connected considerably to the physical distribution of cold chain products, which supports this study's theoretical framework.

4.5 Regression Analysis

Table 5 shows the regression model that was used in analyzing the correlation between the independent variables and the physical distribution of cold chain products. The model has a high correlation coefficient (R = 0.837), indicating a high linear relationship between the predictors and the dependent variable.

Table 5. Regression Analysis

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	DurbinWatson
1	.837[a]	0.701	0.696	3.25753	1.950

The coefficient of determination (R Square) is 0.701, indicating that about 70.1% of the variation in physical distribution is accounted for by the independent variables in the model. The Adjusted R Square of 0.696 supports the good fit of the model after correction for the number of predictors. The estimate's standard error is 3.25753, which is the average distance by which the observed values deviate from the regression line. The Durbin-Watson value is 1.950, which implies there is no serious auto-correlation problem in the regression model residuals.

4.6 Hypothesis Testing

H1: Product timeline does not have a significant positive relationship with physical distribution.

There is no significant positive relationship between product timeline and physical distribution. The correlation between product timeline and physical distribution is statistically significant ($r = 0.626$, $p < 0.01$). However, the regression coefficient for product timeline is negative ($\beta = -0.150$, $p = 0.077$), indicating a weak negative relationship. The p-value for the regression coefficient is greater than 0.05, meaning that the relationship is not statistically significant.

Conclusion: This hypothesis is rejected, as there is no significant positive relationship between product timeline and physical distribution.

H2: Warehouse management has a significant positive relationship with physical distribution.

There is a significant positive relationship between warehouse management and physical distribution. The correlation between warehouse management and physical distribution is statistically significant ($r = 0.818$, $p < 0.01$). The regression analysis shows a positive and highly significant coefficient (β = 1.185, p < 0.001), indicating that improvements in warehouse management positively influence physical distribution. For every unit increase in warehouse efficiency, physical distribution increases by 1.310 units.

Conclusion: This hypothesis is accepted, as warehouse management significantly improves physical distribution.

H3: Transportation does not have a significant positive relationship with physical distribution.

The role of transportation does not have a significant positive relationship with physical distribution. Although the correlation between transportation and physical distribution is very high ($r = 0.931$, $p < 0.01$), the regression analysis reveals a negative coefficient ($\beta = -0.222$, $p = 0.040$). This indicates that improvements in transportation negatively affect physical distribution, with a decrease of 0.291 units for every unit increase in transportation.

Conclusion: This hypothesis is rejected, as the negative regression coefficient contradicts the expected positive impact.

H4: Storage does not have a significant positive relationship with physical distribution.

There is a positive correlation between storage and physical distribution ($r = 0.931$, $p < 0.01$), but the regression analysis reveals a negative coefficient for storage ($\beta = -0.051$, $p = 0.649$), with a p-value greater than 0.05. This indicates that the relationship between storage and physical distribution is not statistically significant.

As show in Table 6, this hypothesis is rejected, as there is no significant positive relationship between storage and physical distribution.

Table 6. Summary of hypothesis testing

Hypothesis	Status
H1: There is a positive relationship between produc timeline and products' physical distribution.	**Not Supported**
H2: There is a positive relationship between warehouse and products' physical distribution.	**Supported**
H3: There is a positive relationship between transporta tion and products' physical distribution.	**Not Supported**
H4: There is a positive relationship between storage and products' physical distribution.	**Not Supported**

5 Discussion

The research examined how four key drivers of operation warehouse, product timeline, transportation, and storage impact cold chain product distribution in Shah Alam, Malaysia. Following the quantitative analysis, the four variables were found to have a statistically significant and positive influence on physical distribution. Warehouse management was the strongest influence, followed by storage, product timeline, and transportation. The results in this chapter are discussed in terms of the research questions and aims, their managerial implications are weighed, and recommendations for enhancing cold chain logistics in Malaysia are offered.

5.1 The Effect of Product Timeline on Physical Distribution

Product timeline had an opposite effect too in the current study. While the bivariate analysis provided a significant positive relationship ($r = 0.626$, $p < 0.01$), a reversed relationship was observed in regression ($\beta = -0.150$, $p = 0.077$) as if it decreases the product timeline, thereby decreasing the physical distribution efficiency further. Previous research emphasizes the importance of on-time deliveries, wherein reducing product timeline delays guarantees product quality and prevents spoilage. Contrary to this, however, our findings are opposed, possibly owing to cold chain logistics complexities wherein reducing product timeline could lead to operational problems elsewhere, such as rushed handling or a lack of adequate storage capacity. This negative correlation may be due to such inefficiencies that are generated when product timelines are compressed but the other areas like transport and warehousing are not supportive. This indicates that the cold chain logistics require an integrated approach and not just focusing on product timeline management. Subsequent research can examine how product timeline intersects with other variables like real-time tracking and logistics optimization to determine the impact of modifications in product timeline on overall distribution efficiency in cold chain networks.

5.2 The Effect of Warehouse Management on Physical Distribution

Warehouse management also positively influenced physical distribution in this study, supporting the hypothesis that physical distribution is enhanced through the efficiency of the warehouse. Regression analysis confirms the presence of a significant relationship ($\beta = 1.185$, $p < 0.001$), which implies that development of warehouse operations, such as faster retrieval time and better storage systems, can enhance physical distribution by 1.310 units significantly. This also aligns with past studies on the roles played by efficient warehouses in maintaining product quality and eradicating logistics bottlenecks [14]. Efficient warehouse management ensures good handling of products to reduce the possibility of spoilage and prevent distribution bottlenecks.Contrary to other studies that highlight physical infrastructure building, our findings show the importance of strategic planning and employee education in warehouses that can have a considerable influence on distribution efficiency. Despite advances in technology in warehouse management, such as automated retrieval and real-time tracking, the human element remains crucial in maximizing performance. Given the encouraging results, subsequent research must explore the use of automation and real-time monitoring systems within warehouses and how these systems support broader supply chain strategies to optimize physical distribution across the cold chain.

5.3 The Effect of Transportation on Physical Distribution

Transportation, although commonly known as a catalyst for increased physical distribution, was not as would be anticipated in this study. Although there was a positive relationship between physical distribution and transportation ($r = 0.931$, $p < 0.01$), its regression analysis had a negative sign ($\beta = -0.222$, $p = 0.040$) showing that there is a decrease in the efficiency of physical distribution by the increase of 0.291 units in the efficiency of transportation. This contradicts the widespread presumption that enhanced transport networks, particularly cold chain management, are decisive inputs to distribution efficiency [10]. Perhaps the theory lies in that transporting upgrades can sometimes cause inefficiencies at other points within the supply chain, e.g., bottlenecks on route deliveries or desynchronized scheduling between transport and warehousing. Cold chain logistics is a highly complex system, and by solving one element, e.g., transportation, without considering the entire supply chain context, it is possible to fail to achieve the desired results. To address this, follow-up research should investigate the ways to integrate transportation with warehouse management systems and logistics coordination to achieve maximum overall distribution effectiveness. Researching innovative technologies like real-time fleet management and predictive analysis may also mitigate the negative impact revealed in this research.

5.4 The Effect of Storage on Physical Distribution

Storage was also expected to exert a positive influence on physical distribution, but the results were not as anticipated. While a high positive correlation was confirmed between storage and physical distribution ($r = 0.931$, $p < 0.01$), a poor and statistically insignificant impact was achieved in the regression model ($\beta = -0.051$, $p = 0.649$), which concludes that physical storage conditions do not have a direct contribution to distribution efficiency. Previous studies highlight the importance of temperature storage in maintaining product quality, especially in cold chain logistics, where improper storage can lead to spoilage or damage. However, our findings show that once storage systems are tailored to product requirements, gains might have diminishing returns on distribution effectiveness. Storage inability to make major contributions may also be due to overlap with warehouse management systems where other factors such as inventory management and retrieval velocity play a more important role. The evidence indicates that companies ought to strive to maximize transport and storage facilities rather than allocating more resources into storage alone. Subsequent studies can explore how new technologies within storage systems, such as automatic cooling systems and energy-efficient storage, can have an effect in order to determine if the new technologies can also improve product quality alongside distribution efficiency.

5.5 Limitation & Recommendation

The study sample included Shah Alam-based cold chain logistics firms whose regional and operational environments restrict generalizability. Self-report data and convenience sampling could have introduced bias, and limitations in accessing realtime system data restricted analysis of logistics interactions. Furthermore, most referred studies are outdated, restricting insights into contemporary technologies such as automation and tracking.

Based on the findings, logistics businesses need to invest in advanced automated warehouse systems and training employees for enhanced distribution efficiency. The management of the product timeline must be optimized using real-time tracking and greater coordination with storage and transport. Infrastructure for transport must be enhanced with refrigerated transport and IoT monitoring to reduce wastage. Storage facilities must install energy-efficient computerized temperature control centers to enhance overall operations. Following studies must broaden their geographical coverage and incorporate qualitative methods to better understand logistics matters.

6 Conclusion

This research finds that warehouse management plays a significant role in physical distribution in cold chain logistics, while product timeline, transport, and storage do not always portray beneficial influences. From the results, it can be shown that reducing timelines or improving transport and storage individually may not enhance the effectiveness of distribution. Instead, there must be a synergistic optimization of all the factors of logistics, among which warehouse management makes the greatest impact. The research emphasizes the interconnectedness and the high level of complexity of cold chain operations and the need to advance research on digital technology and real-time tracking to support logistics performance. The research as a whole effectively achieves its aims by advancing the knowledge of the variables influencing physical distribution.

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