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BUSINESS ADMINISTRATION AND ECONOMICS REVIEW

IMPORTANT FACTORS OF COLD CHAIN MANAGEMENT IN SAMUT PRAKAN PROVINCE

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Abstract

This research aimed to identify the key factors influencing cold chain management in Samut Prakan Province using ANOVA to examine the relationship between the independent and dependent variables and their effectiveness and provide managerial recommendations regarding cold chain management factors. The research variables are independent variables of personal Factors, including Gender, Age, Education, Employees, Business type, and Position, and dependent variables of Cold chain management Factors, including Temperature Monitoring, Transportation Time, Cold Storage Facilities, Packaging Materials, Logistics Coordination, Compliance with Industry Regulations, and Professional Training. The study involved 225 individuals from 48 factories, who work in, have experience with, or are connected to the food cold chain in Samut Prakan Province. Data were analyzed using descriptive statistics, including percentage, mean, and standard deviation, along with inferential statistics through One-Way Analysis of Variance (One-Way ANOVA or F-test with $P < 0.05$).

The findings revealed that most respondents were male, over 50 years old, held undergraduate degrees, worked in companies with 20–50 employees, were engaged in cold storage businesses, and held senior supervisory or supervisory positions. Temperature Monitoring and Compliance with Industry Regulations were identified as the most critical factors for cold chain management in Samut Prakan Province, with mean scores of 4.61 (SD = 0.54) and 4.50 (SD = 0.68), respectively. Additionally, demographic factors such as gender, age, and education significantly influenced all aspects of cold chain management in the province, with a statistical significance level of 0.05. This study provides valuable insights into the demographic influences and critical factors for enhancing cold chain management efficiency, offering practical implications for industry improvement.

Keywords : *Cold Chain Management Factors, Temperature Monitoring, Compliance with Industry Regulations, Demographic Factors*

Introduction

TechSci Research (2024). Said Thailand's cold chain logistics market was valued at USD 928.44 million in 2023 and is anticipated to project robust growth in the forecast period with a CAGR of 6.14% through 2029 as show on Table 1. Advancements in technology, such as IoT-enabled sensors, blockchain, and AI-driven analytics, are revolutionizing cold chain logistics management in Thailand. IoT sensors provide real-time monitoring of temperature humidity conditions during transportation and storage, ensuring compliance with temperature-sensitive requirements. Blockchain technology enhances transparency and traceability in supply chain operations, while AI-driven analytics optimize route planning, inventory management, and resource allocation, thereby improving operational efficiency and reducing waste.

Table 1 Thailand Cold Chain Logistics Market Expected Growth Segmented

Report Description	
Forecast Period	2024-2029
Market Size (2023)	USD 928.44 million
CAGR (2023-2029)	6.41%
Faster Growing Segment	Frozen
Largest Market	Central Region
Market Size (2029)	USD 13.65 billion

Source: TechSci Research, 2024

Cold chain management is an important part of logistics and supply chain operations in Thailand has been steady growth and this is expected to continue in the future. Thailand's cold chain logistics market mainly targeted the business to business (B2B) segment, driven by food, pharmaceutical products and the expansion of convenience stores and restaurants.

In summary, the Thailand Cold Chain Logistics Market is driven by a combination of economic growth, technological innovation, regulatory support, and changing consumer expectations. These drivers underscore the importance of investing in robust cold chain infrastructure, adopting advanced logistics technologies, and aligning with regulatory requirements to meet the evolving needs of industries and consumers reliant on temperature-sensitive logistics solutions.

Despite the logistical technology improvements, cold chain management is a complex logistic chain to manage effectively. This is due to the required constant temperature conditions, the implementation of advanced monitoring technologies, and compliance with strict health and safety standards. Furthermore, the cold chain established within the Thailand logistic system faces a unique challenge due to the country's tropical climate. Disruption of the cold chain leads quickly to spoiled products and loss of market value within the seafood industry. Effective cold chain management is not only vital for the industry that supports the local economy, but it also ensures that the produced goods are of high enough quality to be sold in the international market. In this way, the cold chain logistical management maintains the economic stability of the region dependent on the exported goods and consumer trust in Thai seafood (Han et al. 2021; Prompatanapak & Lopetcharat, 2020).

The efficiency of cold chain logistics poses significant risks not only to the local economy but also to public health. As a major food exporter, Thailand's reputation in the global market depends on its ability to maintain high standards of food safety and quality. The significance of this study lies in its potential to provide feasible insights for improving cold chain logistics in Samut Prakan Province. By identifying the key factors that affect the effectiveness of the cold chain, this research aims to facilitate the development of more efficient, reliable, and sustainable cold chain systems to support the region's growing food industry.

Research objectives

1. To identify the important factors of cold chain management in the Samut Prakan province.

2. To find out the different key factors of demographic data were affected to cold chain management in the Samut Prakan province.

Research Methodology

This study uses quantitative research design by using convenience sampling to collect data from respondents in the cold chain factory and who represent the stakeholders in the food cold chain in Samut Prakan Province.

1. Research Design

This study uses quantitative research design by using purposive sampling from respondents in the cold chain factory, which has a total of 54 factories in Samut Prakan Province. (Department of Industry Work, 2024).

2. Population and Samples

1) Population

The population for this survey research used non-probability sampling 100% of those who work in, have experience with, or are connected to the food cold chain in Samut Prakan Province. The study involved 225 individuals from 48 factories, who replied to an online and an onsite questionnaire from 48 factories in the food cold chain in Samut Prakan Province.

2) Samples

Considering the diversity of the population and the complexity of the research question, the sample size for this study was taken from (Yamane, 1973) with a 95% confidence level and an acceptable error of ± 5%.

The formula is as follows: $S = \frac{N}{1+NE^2}$

N is the number of populations.

S is sample size.

E is an acceptable error at ± 5% (0.05).

$$S = \frac{54}{1 + 54 * 0.05^2}$$

$$S = 47.58 \approx 48$$

Therefore, the sample size should be at least 48 factories in the food cold chain in Samut Prakan Province.

3. Research Instruments

The instrument used in this study is a structured questionnaire to collect quantitative data on various aspects of cold chain representation in Samut Prakan Province. The data can be categorized into 8 sections as follows:

Part 1 Demographic data, consisting of gender, age, the highest level of education, number of employees, role in the food industry, and position in which the question will be closed-ended.

Part 2 - 8 Questionnaire relates to temperature monitoring, transportation time, cold storage facilities, packaging materials, logistics coordination, compliance with industry regulations, and professional training) respectively, using 5 level rating scale, in which 1 means strongly disagree and 5 being strongly agree.

This study will define the criteria for interpretation of mean score from data analysis as follows:

Mean score	Interpretation
1.00-1.49	Strongly disagree
1.50-2.49	Disagree
2.50-3.49	Neutral
3.50-4.49	Agree
4.50-5.00	Strongly agree

4. Quality Control of the Instruments

The instrument for this research is motivated from past research which derived from the literature review in Chapter 2 by selecting variables instrument as follows, temperature monitoring, transportation time, cold storage facilities, packaging materials, logistics coordination, compliance with industry regulations, and professional training. This research tested the quality by checking the validity of the questionnaire and checking the reliability of the questionnaire, with details as follows:

1) Validity

The questionnaire obtained from studying related research documents was submitted to the advisor for consideration and for qualified persons/subject-specific experts to consider checking the content validity, which is checking the comprehensiveness of the measurement in the content of the thing to be measured, and checking the construct validity, which is measuring from various concepts and rules with the specified properties, totaling 3 persons.

The results of the examination of each question by 3 experts are summarized as follows:

(1) Demographic data, statistical tool used will be frequency distribution and percentage. IOC calculation results 1.00, IOC analysis results are acceptable content.

(2) Perception on temperature monitoring, the statistical tool used is mean and standard deviation. IOC calculation results 0.93, IOC analysis results are acceptable content.

(3) Perception on transportation time, cold storage facilities, packaging materials, logistics coordination, compliance with industry regulations, and professional training), respectively. The statistical tool used is mean and standard deviation. IOC calculation results 1.00, IOC analysis results are acceptable content.

2) Reliability

The results demonstrate excellent internal consistency, with a Cronbach's Alpha value of 0.945 from 30 questionnaires. When considering standardized items, Cronbach's Alpha value increased to 0.954 from 225 questionnaires, indicating a highly reliable set of questions.

5. Data Collection

The researcher distributed the questionnaire by sending a link and QR code to some factories and by visiting the factories in person for respondents to scan and fill out the questionnaire, reply to a total of 225 responses from 48 factories.

Data analysis will be performed using statistical software. The analysis will include descriptive statistics to summarize the data, and inferential statistics to test hypotheses and determine relationships between variables. The statistics used for data analysis are as follows:

Part 1 Demographic data, statistical tool used will be frequency distribution and percentage.

Part 2 Perception of the importance factors of cold chain management in terms of temperature monitoring, transportation time, cold storage facilities, packaging materials, logistics coordination, compliance with industry regulations, and professional training, the statistical tool used is mean and standard deviation.

Part 3 The different key factors of demographic data were affected by all cold chain management factors in the Samut Prakan province, the data using along with inferential statistics through One-Way Analysis of Variance (One-Way ANOVA).

Research Results

1. Demographic Data Analysis

Demographic data includes gender, age, highest level of education, number of employees, type of business, and position in the company. Details are as follows:

Table 2 Results of demographic data analysis (n=225)

Variables		Frequency	Percentage
Gender	Male	147	65.3
	Female	68	30.2
	Third gender	10	4.4
	Total	225	100

Table 2 Results of demographic data analysis (n=225) (next)

Variables		Frequency	Percentage
Age	Less than 30 years	26	11.6
	30-40 years	61	27.1
	41-50 years	45	20
	Over 50 years	93	41.3
	Total	225	100
Highest level of education	High school	37	16.4
	Undergraduate	116	51.6
	Bachelor's degree	55	24.4
	Master's degree or upper	17	7.6
	Total	225	100
Number of employees in the company	Less than 20 staffs	24	10.7
	20-50 staffs	72	32
	51-100 staffs	70	31.1
	101-200 staffs	14	6.2
	More than 200 staffs	45	20
	Total	225	100
Type of business	Cold storages	215	95.6
	Logistics service provider	6	2.7
	Buyer	4	1.8
	Total	225	100
Position in the company	Owner	6	2.7
	Director	6	2.7
	Manager / Assistant Manager	62	27.6
	Senior Supervisor / Supervisor	151	67.1
	Total	225	100

Analysis of the demographic data of the sample respondents using descriptive statistics from Table 2 found that summarizing the results of the demographic analysis of the sample respondents revealed several key characteristics. Most of the group consists of a male, over 50 years old, with undergraduate education, employed in companies with 20-50 staff members, in cold storage businesses, and with senior supervisory or supervisory position.

2. Variables Data Analysis

The results of the analysis of descriptive statistics, namely the mean and the standard deviation of each variable consisted as follows:

Table 3 Results of data analysis on variables (n=225)

Variables	Mean	Standard deviation	Interpretation
1.Temperature Monitoring	4.61	0.54	Strongly agree
2.Transportation Time	3.91	0.93	Agree
3.Cold Storage Facilities	4.42	0.56	Agree
4.Packaging Materials	4.34	0.71	Agree
5.Logistics Coordination	4.45	0.70	Agree
6.Compliance with Industry Regulations	4.50	0.68	Strongly agree
7.Professional Training	4.26	0.80	Agree

The analysis results of variables from Table 3 show that the importance of cold chain management factors was Strongly agree consensus on Temperature Monitoring (Mean = 4.61, S.D. = 0.54), and Compliance with Industry Regulations (Mean = 4.50, S.D. = 0.68). Agree consensus on Logistics Coordination (Mean = 4.45, S.D. = 0.70), Cold Storage Facilities (Mean = 4.42, S.D. = 0.56), Packaging Materials (Mean = 4.34, S.D. = 0.71), Professional Training (Mean = 4.26, S.D. = 0.80) and Transportation Time (Mean = 3.91, S.D. = 0.93).

Summarizing the importance factor of cold chain management in Samut Prakan Province were Temperature Monitoring and Compliance with Industry Regulations (Mean = 4.61, S.D. = 0.54 and Mean = 4.50, S.D. = 0.68).

3. Hypothesis test for variables

The hypothesis test using One-Way ANOVA or F-test with $P < 0.05$ show that: on Table 4 Gender differences, Age differences, and Education differences affected the factors of cold chain management at the significance level of 0.05. The dependent variable is quantitative data (Independent Sample F-test), found that different departments have different opinions on Factors of Cold Chain Management of Gender in terms of Temperature Monitoring, Transportation Time, Cold Storage Facilities, Packaging Materials, Logistics Coordination, Compliance with Industry Regulations and Professional Training.

Table 4 Results of the comparison of Gender, Age and Education on factors of cold chain management

Factors of Cold Chain Management	Gender		Age		Education	
	F	Sig (2-tailed)	F	Sig (2-tailed)	F	Sig (2-tailed)
Temperature Monitoring	5.441	0.005*	16.779	0.000**	6.867	0.000**
Transportation Time	26.059	0.000**	26.059	0.000**	5.000	0.002*
Cold Storage Facilities	16.779	0.000**	16.779	0.000**	6.867	0.000**
Packaging Materials	11.031	0.000**	23.601	0.000**	5.664	0.001*
Logistics Coordination	34.357	0.000**	34.357	0.000**	3.214	0.004*
Compliance with Industry Regulations	61.730	0.000**	61.730	0.000**	27.089	0.000**
Professional Training	5.441	0.005*	38.662	0.000**	18.042	0.000**

Note: ** Statistically significant at 0.05 level

Table 5 Results of the comparison of Employees, Business Type and Position on factors of cold chain management

Factors of Cold Chain Management	Employees		business type		Position	
	F	Sig (2-tailed)	F	Sig (2-tailed)	F	Sig (2-tailed)
Temperature Monitoring	2.910	0.052	0.000	1.000	1.128	0.338
Transportation Time	2.173	0.073	0.566	0.568	1.150	0.330
Cold Storage Facilities	2.910	0.052	0.000	1.000	1.128	0.338
Packaging Materials	1.751	0.140	0.097	0.907	2.850	0.038
Logistics Coordination	1.085	0.365	1.161	0.315	2.952	0.034
Compliance with Industry Regulations	1.069	0.373	0.102	0.903	1.160	0.188
Professional Training	1.309	0.238	0.023	0.759	6.043	0.061

Note: ** Statistically significant at 0.05 level

Table 5 the results of the comparative analysis of Factors of Cold Chain Management of Employees differences, Business type differences, and Position differences were not affected on factors of Cold Chain Management in terms of Temperature Monitoring, Transportation Time, Cold Storage Facilities, Packaging Materials, Logistics Coordination, Compliance with Industry Regulations and Professional Training, with the significance level of 0.05.

Conclusion and Discussion

1. Conclusions of Study

This study explores seven key factors in cold chain management within the food industry in Samut Prakan Province, Thailand found that,

1) The demographic analysis, most of the group consists of a male, over 50 years old, with undergraduate education, employed in companies with 20-50 staff members, in cold storage businesses, and with senior supervisory or supervisory positions.

2) Temperature Monitoring and Compliance with Industry Regulations were the important factors of cold chain management in Samut Prakan Province with mean scores of 4.61 (S.D. = 0.54) and 4.50 (S.D. = 0.68), respectively.

3) The comparative analysis using One-Way ANOVA or F-test revealed that the different key factors of demographic data in term of gender, age, and education were affected to all cold chain management factors in the Samut Prakan province, include Temperature Monitoring, Transportation Time, Cold Storage Facilities, Packaging Materials, Logistics Coordination, Compliance with Industry Regulations, and Professional Training, with statistically significant differences observed at the 0.05 level.

2. Discussions of Findings

1) The demographic analysis of the sample group reveals that respondents are predominantly male, over 50 years old, and hold undergraduate degrees. They mainly work in companies with 20-50 staff members, within the cold storage industry, and occupy senior supervisory or supervisory positions. This demographic profile provides essential context for understanding respondent perspectives on cold chain management, as individual characteristics can heavily

influence these perceptions, according to previous research studies by Gottfredson and Daiger (1977), found that, demonstrating increased gender diversity across occupations while emphasizing the persistence of gender segmentation in specific fields, which is consistent with Humpert and Pfeifer (2013), who noted that factors like age and job position shape career satisfaction and job perceptions, while Naafs (2013) highlighted the role of educational background and cultural expectations in shaping professional outlooks, and also consistent with Corleto and Esparza (2021) found the significance of gender inequalities in engineering and technical education, where masculine work cultures and gender norms hinder women's participation and career advancement.

2) The temperature monitoring was the first important factors of cold chain management in Samut Prakan Province with a mean of 4.61 and standard deviation of 0.54, according to previous research studies by Yan and Lee (2009) demonstrated the importance of RFID-based systems integrated with GPS and temperature sensors, which enable real-time tracking and adjustment of temperature conditions during transportation. This aligns with the need for precise temperature control to mitigate risks. Similarly, Mercier et al. (2017) highlight temperature control as essential for preserving product quality and preventing spoilage across the supply chain, while Nastasijević et al. (2017) underscored the role of temperature monitoring in preventing microbial growth and spoilage, particularly for perishable products like meat, where even minor temperature fluctuations can compromise safety and freshness. Further supporting these findings, which is consistent with Chaitangjit and Ongkunaruk (2019) emphasize the role of transportation and cold storage infrastructure in maintaining temperature stability, reflecting respondent concerns, and consistent with Ye et al. (2022) also underscore the significance of IoT-enabled temperature monitoring systems in modern cold chains, noting that real-time monitoring allows prompt corrective actions to ensure product safety.

Also, the compliance with industry regulations was the second important factors of cold chain management in Samut Prakan Province with a mean of 4.50 and standard deviation of 0.68, according with previous research, Peng (2013) found that the importance of regulatory awareness among employees, particularly in regions with outdated systems, emphasizing that consistent training ensures adherence to standards even under less advanced conditions, which is consistent with An et al. (2015) found that the critical role of regulatory frameworks in maintaining food quality from production to consumption, stressing the necessity of consistent application of standards, including

temperature control and handling protocols, and consistent with Yang et al. (2022) and Wang et al. (2023) found the demonstrated the growing significance of international standards like HACCP in identifying hazards and implementing preventive measures within cold chain processes. These studies collectively affirm that strict adherence to regulations is vital for maintaining the integrity, safety, and quality of cold chain operations, supporting the conclusion that compliance is a priority for respondents.

3) The different key factors of demographic data in terms of gender, age, and education were affected by all cold chain management factors in the Samut Prakan province, with a statistical significance of 0.05, including Temperature Monitoring, Transportation Time, Cold Storage Facilities, Packaging Materials, Logistics Coordination, Compliance with Industry Regulations, and Professional Training. According to previous research studies by Humpert and Pfeifer (2013) found demonstrate how demographic factors like age and gender influence employment patterns and wage levels, underscoring the relevance of these variables to workforce dynamics in cold chain operations. Similarly, Naafs (2013) highlights how education shapes career trajectories, particularly in contexts with gender and cultural expectations, reinforcing the role of demographic characteristics in professional development, which is consistent with the connection between demographics and professional performance is further emphasized in Corleto and Esparza (2021) research, which examines gender disparities in technical education and workforce participation, a critical factor in industries reliant on specialized training like cold chain management, while The findings align with the importance of structured training programs, as highlighted by Singh et al. (2018) which prepare employees for technological advancements and regulatory compliance. Higher education levels and managerial roles correlate with a greater emphasis on logistics coordination and regulatory compliance, aligning with An et al. (2015), who found that experienced or senior personnel tend to prioritize compliance to mitigate operational risks due to their greater knowledge of industry regulations. Moreover, the integration of IoT systems in cold chain logistics, as discussed by Tsang et al. (2017), requires workforce proficiency, which varies across demographic groups.

3. Recommendations

Based on the insights from this study, The Entrepreneur's cold chain management in Samut Prakan Province. should understand and manage the differences in gender, age, and education to improve and manage their business with high technology for future business growth, future research could explore additional variables that may impact cold chain management in Thailand. For instance, examining the role of emerging technologies such as blockchain or advanced data analytics could provide valuable information on further strengthening cold chain operations. Expanding the scope to include other industries heavily reliant on cold chain logistics, such as the pharmaceutical industry, would offer a comparative perspective and broaden the understanding of cold chain challenges across different sectors.

Methodologically, future research could benefit from incorporating qualitative research methods, such as interviews or focus groups, to gain more nuanced perspectives and experiences from cold chain stakeholders. Additionally, exploring cold chain management across multiple provinces or regions could enhance the generalizability of findings and provide a more comprehensive view of the cold chain landscape in Thailand.

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