Siber Journal of Advanced Multidisciplinary (SJAM)
E-ISSN: 2987-1069
P-ISSN: 2987-1018
Siber Nusantara Research
+62 812 1046 7572 https://research.e-siber.org research.siber.info@gmail.com Jalan Marina Indah Raya No. 1 Pantai Indah Kapuk, Kamal Muara, Penjaringan, Jakarta Utara, Indonesia.

DOI: https://doi.org/10.38035/sjam.v2i1
Received: May 6th 2024, **Revised:** May 8th 2024, **Publish:** May 12th 2024

Determinant of Agricultural Cold Chain: Study Case Approach

Atong Soekirman
Institut Transportasi dan Logistik Trisakti, Jakarta, Indonesia, Email: a.soekirman@gmail.com

Corresponding Author: a.soekirman@gmail.com

Abstract: The purpose of this research is to promote innovation in the development of technology and management solutions that can improve the overall performance of the cold chain. By identifying research gaps and lingering challenges in managing agricultural cold chains, this research aims to encourage the development of new and sustainable solutions that can improve operational efficiency, reduce waste, and improve product quality. This research is quantitative research by making observations to the respondent. The respondents who completed the questionnaire were farmers who use logistics services in Bekasi and its surroundings. Questionnaire questions are distributed directly to respondents. Data analysis in this study uses SPSS 25 by looking for the results of the influence between existing variables, namely independent and dependent variables. Harvest Handling and Electricity variables are not significant in influencing Cold Agriculture, while Cold Storage and Reefer Containers have a significant influence. Therefore, pay more attention to effective cold storage practices and integration of reefer containers in improving the quality and efficiency of agricultural cold chains. This could include improved cold storage infrastructure, the use of more advanced technology in reefer container management, and increased training for practitioners in equipment handling and use.

Keywords: Harvest Handling, Electricity, Cold Storage, Reefer Container, Agriculture Coldchain

INTRODUCTION

In modern agriculture, cold chain efficiency is essential to maintain quality and extend the shelf life of perishable products. This requires a holistic approach involving a variety of factors, including crop handling, power supply, cold storage facilities, and reefer container integration. In terms of agricultural cold chains, the relationship between various variables such as crop handling, power supply, cold storage, and reefer container integration has a direct impact on the overall efficiency and success of the system (Hu, Xiang and Qi, 2021).

In many logistics companies, especially those operating in the supply chain of perishable products such as fresh food or pharmaceuticals, there is an increasing awareness of the importance of maintaining product quality and freshness during transportation. This encourages these companies to continuously improve their infrastructure and processes to optimize the cold chain, which involves handling harvests, using power supplies, cold storage facilities, and integrating reefer containers (Chen, Arip and Bakar, 2024).

However, there are a number of issues that logistics companies still face in managing their cold chains effectively (Xudong and Feiyan, 2023). One is the availability of stable and reliable electricity, especially in rural areas or developing countries where electricity infrastructure may be underdeveloped. Power interruptions can cause temperatures in cold storage facilities to go unchecked, resulting in damage to products and financial losses for the company (Zhao, Ye and Jang, 2023).

Efficient handling of harvests plays an important role in maintaining the quality and freshness of agricultural products before they enter into cold storage facilities (Acedo, 2019). If the harvest is done poorly, for example, the crop can be physically damaged or contaminated, resulting in significant losses even before the product enters the cold storage stage. A stable and reliable power supply is essential to maintain optimal functioning of cold storage facilities (Lam, Tang and Ho, 2023). Power interruptions or blackouts can cause temperatures in cold storage rooms to be unmaintained, resulting in damage or spoilage to stored agricultural products (Paul *et al.*, 2024). Reefer containers require a continuous supply of electricity during transportation to maintain the desired temperature conditions inside (Ikegaya *et al.*, 2022). Unstable or interrupted power supplies during travel can cause damage to transported agricultural products and disrupt the cold chain as a whole (Yadav, Korakana and Rao, 2022).

Upon reaching its destination, reefer containers require adequate cold storage facilities to keep agricultural products fresh until they are ready for distribution to markets or end consumers (Jolly, 2020). The availability of adequate cold storage facilities and sufficient capacity will ensure that agricultural products are maintained in quality during the post-transportation storage process (Das and Mahapatra, 2022). The way agricultural products are harvested and packaged also impacts the ability to integrate reefer containers in the cold chain. If harvesting and packaging are done well, agricultural products will be easier to load into reefer containers and properly arranged to maintain their quality during transportation (Budiyanto *et al.*, 2023).

In addition, there are also challenges associated with managing and maintaining cold storage facilities (Sivakumar and Ruthramathi, 2019). Some companies may face constraints in the initial investment required to build or update cold storage facilities that conform to the required standards. High operational costs and lack of understanding of efficient technology can also be obstacles for logistics companies (Silin, 2021). The gap in this research is the lack of focus on holistic integration of various elements in the agricultural cold chain, such as crop handling, power supply, cold storage, and reefer container integration (Aithal, Dillon and Grice, 2020). Many existing studies tend to focus on one particular aspect of the cold chain, without thoroughly considering how all these variables are related and influential to each other (Khazaeli, Jabalameli and Sahebi, 2023).

The novelty of the proposed research is a holistic and integrated approach in optimizing the agricultural cold chain. While much of previous research has focused on one particular aspect of the cold chain, such as cold storage technology or power supply management, this research will explore the complex relationships between various variables in the cold chain, from crop handling to reefer container integration .(Aithal, Dillon and Grice, 2020)

The purpose of this research is to promote innovation in the development of technology and management solutions that can improve the overall performance of the cold chain. By identifying research gaps and lingering challenges in managing agricultural cold chains, the aim of this research is to encourage the development of new and sustainable solutions that can improve operational efficiency, reduce waste, and improve product quality.

Harvest Handling

Harvest Handling refers to a series of processes and techniques used to collect, process, and prepare agricultural harvests for further storage or distribution. The aim is to maintain the quality and freshness of agricultural products and minimize post-harvest losses (Kader, 2002).

The harvest handling process includes a variety of activities, such as the collection of crops from fields, selection and separation of quality products from unfit ones, cleaning, cutting or separating certain parts of the crop, and packaging for transportation or storage. These practices are carefully carried out to reduce physical damage, injury, or contamination that may affect product quality and shelf life (Dos Santos *et al.*, 2020). Research related to this variable states Technological developments show that the latest techniques such as ultrasonication, ozonation, and analysis of loss aspects during the process using the e-nose method and the Taguchi approach can also be a solution (Indiarto, Izzati and Djali, 2020).

Other studies state the positive health effects arising from regular coffee consumption, which are related to phytochemicals present in coffee beans. However, phytochemicals must be available in sufficient quantities at the time of ingestion in order to provide beneficial health effects (Munyendo *et al.*, 2021).

Electricity

Refers to the use of electric power in logistics operations to meet various needs, ranging from vehicle propulsion and material handling equipment In modern logistics operations, electrical technology is also constantly evolving to improve efficiency and productivity. These include the use of electric or hybrid vehicles in freight transportation, the implementation of energy storage systems to reduce peak power costs, and the application of green technologies to minimize the carbon footprint of logistics operations (Waters and Rinsler, 2014). Another definition expresses the provision of energy for cold storage systems and processing facilities. In the context of logistics, electricity is used to run various equipment and systems that enable efficient transportation, stock management, and processing of goods (Mangan and Lalwani, 2016).

Related research states the effectiveness of the proposed model by determining optimal decisions for the generation and transmission of renewable electricity. Sensitivity analysis shows that the level of subsidies for renewable electricity production has a major impact on decisions (Osmani and Zhang, 2014). Further research reveals a better understanding of RL/CLSC's activities and research focusing on WEEE (Islam and Huda, 2018).

Cold Storage

Cold storage is a facility or storage room specifically designed to maintain low temperatures to extend the shelf life of temperature-sensitive products, such as frozen foods, meat products, fruits, and vegetables. Cold storage facilities are usually equipped with cooling systems that can control temperature precisely so that these products remain fresh and avoid damage (Sun, 2005) It also states a method or practice in the supply chain of keeping products in cold or freezing conditions to maintain their quality during storage and transportation. This involves the use of cold storage facilities, reefer containers, and other refrigeration technologies to keep product temperatures below a certain threshold (Tomczyk *et al.*, 2017).

Other studies have also stated that it has a positive effect on quality maintenance during transportation when the ratio of bud mass to CSA is 15:8 and the volume ratio of Styrofoam and CSA containers is 10:1 (Guo *et al.*, 2022). The agricultural cold chain logistics system has great significance for the preservation of agricultural products and reducing losses. Moreover, it significantly increases farmers' incomes and rural revitalization in China, to some degree (Zhao *et al.*, 2022).

Reefer Container

A reefer container is a special type of container equipped with a cooling system to control the temperature inside. These containers are used to transport goods that require controlled temperatures, such as frozen foods, fresh products, or temperature-sensitive pharmaceutical items (James, 2019) Another definition states a type of cargo container that is equipped with a cooling system to maintain the temperature inside at a certain level during transportation. These containers are often used to transport goods that require strict temperature control, such as frozen foods, fruits, vegetables, and pharmaceutical products (Castelein, Geerlings and Van Duin, 2020).

Related research from (Kan *et al.*, 2021) Stated the temperature of cargo piles adjacent to the inlet and outflow air flow will rise relatively quickly, due to the stronger intensity of surface heat transfer and the amount of heat permeation from the outside. In addition, the rate of temperature change of cargo in different positions in the same stack is also different. As a future trend, we expect a further reduction in carbon footprint and progress in digital mapping of refrigerated containers and their cargo to monitor and predict future fruit and vegetable quality during transit and beyond (Lukasse *et al.*, 2023).

METHOD

This research is a quantitative research by making observations to the respondent. The respondents who became the questionnaire were farmers who use logistics services in Bekasi and its surroundings. Questionnaire questions are distributed directly to respondents. Data analysis in this study uses SPSS 25 by looking for the results of the influence between existing variables, namely independent and dependent variables.

RESULTS AND DISCUSSION

Result

After distributing the questionnaire to respondents with statements in the questionnaire, the answers returned to the researcher were 39 respondents. Data processing using SPSS 25, with the answers to the analysis results as follows below:

Descriptive Statistical Test Results

Table 1. Descriptive Statistical Test Results

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Harvest Handling	39	29	50	39.33	5.397
Electricity	39	29	50	39.18	4.941
Cold Storage	39	29	47	38.05	4.249
Refeer Container	39	28	50	37.97	5.580
Agriculture Coldchain	39	28	49	38.21	5.686
Valid N (listwise)	39				

SPSS 25 data processing results. 2024

These descriptive statistics provide an idea of the distribution and variation of data on each variable. The range of values, mean, and standard deviation helps in understanding the distribution of data and the degree of variability among the observed samples. From those results, we can see that the average value for each variable is somewhere around 38 to 39, with some variation in the range of values. A relatively small standard deviation indicates that the data tend to converge around mean values, although there is little variation among samples.

Correlation Test Results

Table 2. Correlation Test Results

Correlations

		Harvest Handling	Electricity	Cold Storage	Refeer Container	Agriculture Coldchain
Harvest Handling	Pearson Correlation	1	.709**	.644**	.815**	.833**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	39	39	39	39	39
Electricity	Pearson Correlation	.709**	1	.636**	.815**	.838**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	39	39	39	39	39
Cold Storage	Pearson Correlation	.644**	.636**	1	.707**	.749**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	39	39	39	39	39
Refeer Container	Pearson Correlation	.815**	.815**	.707**	1	.980**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	39	39	39	39	39
Agriculture Coldchain	Pearson Correlation	.833**	.838**	.749**	.980**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	39	39	39	39	39

**. Correlation is significant at the 0.01 level (2-tailed).

SPSS 25 data processing results. 2024

From the results of the Pearson correlation, we can see a significant relationship between various variables in the context of agricultural cold chain optimization. A significant positive correlation indicates that the higher the value of one variable, the higher the value of the other variable, and vice versa.

Multiple Regression Test Results

Table 3. Multiple Regression Test Results

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-3.811	1.612		-2.364	.024
	Harvest Handling	.076	.054	.072	1.419	.165
	Electricity	.104	.059	.090	1.773	.085
	Cold Storage	.123	.056	.092	2.181	.036
	Refeer Container	.797	.065	.782	12.193	.000

a. Dependent Variable: Agriculture Coldchain

SPSS 25 data processing results. 2024

From the data obtained above from the results of the Multiple Regression test, then:

$$Y = -3.811 + 0076X_1 + 0{,}104\ X_2 + 0.123X_3 + 0.797X_4 +$$

Y is the predicted value for the dependent variable (in this context, the Agriculture Coldchain). X1, X2, X3, and X4 are the values of the independent variables Harvest Handling, Electricity, Cold Storage, and Reefer Container respectively. The coefficients of each independent variable showed their relative influence on the Agriculture Coldchain value after controlling for the effects of other variables in the model. It shows how regression models can be used to understand the relationships between variables in a system and to make predictions about the value of the dependent variable based on the value of a given independent variable.

T Test Results

Table 4. T Test Results

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-3.811	1.612		-2.364	.024
	Harvest Handling	.076	.054	.072	1.419	.165
	Electricity	.104	.059	.090	1.773	.085
	Cold Storage	.123	.056	.092	2.181	.036
	Refeer Container	.797	.065	.782	12.193	.000

a. Dependent Variable: Agriculture Coldchain

SPSS 25 data processing results. 2024

In the t-test results that you provide, there are four regression coefficients that are tested for significance, namely for the variables Harvest Handling, Electricity, Cold Storage, and Reefer Container. Here is the analysis: Harvest Handling, The regression coefficient for Harvest Handling is not statistically significant at a 95% confidence level. This means that harvest handling does not have a significant effect on the Agriculture Coldchain after considering other variables in the model. The regression coefficient for electricity is also not statistically significant at a 95% confidence level. This showed that electricity use did not have a significant effect on coldchain agriculture after considering other variables in the model.

The regression coefficient for cold storage is statistically significant at a 95% confidence level. This suggests that cold storage has a significant influence on coldchain agriculture after considering other variables in the model.

The regression coefficient for Reefer Container is statistically significant at a 95% confidence level. This shows that the integration of reefer containers has a very significant influence on Agriculture Coldchain after considering other variables in the model.

Thus, from the results of this t-test analysis, we can conclude that the Cold Storage and Reefer Container variables have a significant influence on Agriculture Cold Chain, while the Harvest Handling and Electricity variables are not statistically significant.

F Test Results

Table 5. F Test Results

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1193.167	4	298.292	288.191	.000[b]
	Residual	35.192	34	1.035		
	Total	1228.359	38			

a. Dependent Variable: Agriculture Coldchain

b. Predictors: (Constant), Refeer Container, Cold Storage, Electricity, Harvest Handling

SPSS 25 data processing results. 2024

The results of the F test analysis (ANOVA) show the overall significance of the multiple linear regression model used to predict the dependent variable Agriculture Coldchain. Following the interpretation of the results, the regression model as a whole was significant at a significance level of 0.000 (p-value < 0.05). This suggests that at least one of the independent variables had a significant influence on the Agriculture Coldchain dependent variable, hence a high F value (288,191) indicates that the independent variables together account for significant variation in the Agriculture Coldchain dependent variable. The mean square error (Residual) is 1.035, which indicates a degree of variability that cannot be explained by the model.

Thus, the results of this F test confirm that the regression model used significantly explains the variation in the dependent variable Agriculture Coldchain.

Coefficient of Determination Test Results

Table. Coefficient of Determination Test Results

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.986[a]	.971	.968	1.017

a. Predictors: (Constant), Refeer Container, Cold Storage, Electricity, Harvest Handling

SPSS 25 data processing results. 2024

With high R Square and Adjusted R Square values, as well as low Std. Error of the Estimate values, it shows that multiple linear regression models used are quite good at explaining and predicting Agriculture Coldchain dependent variables.

DISCUSSION

Cold Storage and Reefer Container variables have a significant influence on Agriculture Cold Chain, while Harvest Handling and Electricity variables are not statistically significant. This demonstrates the importance of cold storage and reefer container integration in improving overall efficiency and quality in the agricultural cold chain. These findings could form the basis for more effective strategies and policies in agricultural cold chain management.

CONCLUSION

Harvest Handling and Electricity variables are not significant in influencing Cold Agriculture, while Cold Storage and Reefer Containers have a significant influence. Therefore, to pay more attention to effective cold storage practices and integration of reefer containers in improving the quality and efficiency of agricultural cold chains. This could include improved cold storage infrastructure, the use of more advanced technology in reefer container management, and increased training for practitioners in equipment handling and use. By improving these aspects, we can improve the quality and durability of agricultural products during transportation and storage, which in turn will support the growth and sustainability of the agricultural industry.

REFERENCES

Acedo, A.L. (2019) 'Postharvest handling and storage technologies for fresh horticultural produce', *Acta Horticulturae* [Preprint]. Available at:

https://api.semanticscholar.org/CorpusID:202911084.

Aithal, P.S., Dillon, M. and Grice, R. (2020) 'Solar Cold Chain Optimization Research – An Integrated Multidisciplinary Project Agenda', *Industrial \& Manufacturing Engineering eJournal* [Preprint]. Available at: https://api.semanticscholar.org/CorpusID:237530488.

Budiyanto, M.A. *et al.* (2023) 'Airflow Distribution Analysis of Reefer Container with Skipjack Tuna Load using Computational Fluid Dynamics', *CFD Letters* [Preprint]. Available at: https://api.semanticscholar.org/CorpusID:266099633.

Castelein, B., Geerlings, H. and Van Duin, R. (2020) 'The reefer container market and academic research: A review study', *Journal of Cleaner Production*, 256, p. 120654.

Chen, Y., Arip, M.A. and Bakar, N.A.A. (2024) 'Cold Chain Logistics Demand Forecasting for Fresh Agricultural Foods in Fujian Province, China', *International Journal of Religion* [Preprint]. Available at: https://api.semanticscholar.org/CorpusID:268961771.

Das, U. and Mahapatra, A. (2022) 'Affordable cold storage for preservation of perishable agricultural products in the context of North Bengal', *Journal of Mechanical Engineering: Prakash* [Preprint]. Available at: https://api.semanticscholar.org/CorpusID:251638665.

Guo, X. *et al.* (2022) 'Cold storage agent as a treatment to maintain quality of peanut sprouts in logistics', *Journal of Agriculture and Food Research*, 9, p. 100317.

Hu, L., Xiang, C. and Qi, C. (2021) 'Optimization of VRR for Cold Chain with Minimum Loss Based on Actual Traffic Conditions', *Wireless Communications and Mobile Computing* [Preprint]. Available at: https://api.semanticscholar.org/CorpusID:245068491.

Ikegaya, A. *et al.* (2022) 'Transportation via containers at ice temperature inhibits decay and maintains the quality of certain fresh produce', *CyTA - Journal of Food*, 20, pp. 285–296. Available at: https://api.semanticscholar.org/CorpusID:253074957.

Indiarto, R., Izzati, A.N. and Djali, M. (2020) 'Post-harvest handling technologies of tropical fruits: A review', *International Journal*, 8(7), pp. 3951–3957.

Islam, M.T. and Huda, N. (2018) 'Reverse logistics and closed-loop supply chain of Waste Electrical and Electronic Equipment (WEEE)/E-waste: A comprehensive literature review', *Resources, Conservation and Recycling*, 137, pp. 48–75.

James, C. (2019) 'Food transportation and refrigeration technologies—Design and optimization', in *Sustainable Food Supply Chains*. Elsevier, pp. 185–199.

Jolly, L. (2020) 'Food Cold Chain Management System – From a Structured Theoretical Analysis to a Conceptual Framework on Perishable Commodities in India', in. Available at: https://api.semanticscholar.org/CorpusID:231831743.

Kader, A.A. (2002) *Postharvest technology of horticultural crops*. University of California Agriculture and Natural Resources.

Kan, A. *et al.* (2021) 'The characteristics of cargo temperature rising in reefer container under refrigeration-failure condition', *International Journal of Refrigeration*, 123, pp. 1–8.

Khazaeli, S., Jabalameli, M.S. and Sahebi, H. (2023) 'Bi-objective model for multi-level supply chain by focusing on quality of agricultural products: a case study', *Kybernetes* [Preprint]. Available at: https://api.semanticscholar.org/CorpusID:259015409.

Lam, H.Y., Tang, V. and Ho, G.T.S. (2023) 'Design of Closed-Loop Cold Chain Logistics Optimization Model', *2023 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, pp. 315–319. Available at: https://api.semanticscholar.org/CorpusID:267385418.

Lukasse, L.J.S. *et al.* (2023) 'Perspectives on the evolution of reefer containers for transporting fresh produce', *Trends in Food Science & Technology*, p. 104147.

Mangan, J. and Lalwani, C. (2016) *Global logistics and supply chain management*. John Wiley & Sons.

Munyendo, L.M. *et al.* (2021) 'Coffee phytochemicals and post-harvest handling—A complex and delicate balance', *Journal of Food Composition and Analysis*, 102, p. 103995.

Osmani, A. and Zhang, J. (2014) 'Optimal grid design and logistic planning for wind and biomass based renewable electricity supply chains under uncertainties', *Energy*, 70, pp. 514–528.

Paul, A.A. *et al.* (2024) 'Design and Construction of a Rapid Milk Chiller Using Cold Energy Storage System in the Context of Bangladesh', *IOP Conference Series: Materials Science and Engineering* [Preprint]. Available at: https://api.semanticscholar.org/CorpusID:269231359.

Dos Santos, S.F. *et al.* (2020) 'Post-harvest losses of fruits and vegetables in supply centers in Salvador, Brazil: Analysis of determinants, volumes and reduction strategies', *Waste Management*, 101, pp. 161–170.

Silin, Y.A. (2021) 'Development of the Information-Measuring System to Maintain the Temperature Balance Inside the Container During Transportation', *2021 Wave Electronics and its Application in Information and Telecommunication Systems (WECONF)*, pp. 1–4. Available at: https://api.semanticscholar.org/CorpusID:236188165.

Sivakumar, V.J. and Ruthramathi, R. (2019) 'Challenges and Features of Warehousing Operations with Respect to Logistics Warehouse Companies in Chennai', *International Journal of Innovative Technology and Exploring Engineering* [Preprint]. Available at: https://api.semanticscholar.org/CorpusID:212485374.

Sun, D.-W. (2005) *Handbook of frozen food processing and packaging*. CRC press.

Tomczyk, J. *et al.* (2017) *Refrigeration and air conditioning technology*. Cengage Learning Boston, MA, USA.

Waters, D. and Rinsler, S. (2014) *Global logistics: New directions in supply chain management*. Kogan Page Publishers.

Xudong, X. and Feiyan, L. (2023) 'Analysis on cold Chain Logistics Informatization Construction of Blockchain Technology', *International Journal of Science and Engineering Applications* [Preprint]. Available at: https://api.semanticscholar.org/CorpusID:256180244.

Yadav, J.S., Korakana, S. and Rao, C.M. (2022) 'Mini cold storage using the parabolic solar trough: An appropriate technology for perishable agricultural product', in. Available at: https://api.semanticscholar.org/CorpusID:248395714.

Zhao, J., Ye, F. and Jang, G.W. (2023) 'Research on the Influencing Factors of the Dual System of Agricultural Product E-commerce and Cold Chain Logistics under Low-carbon Economy', *2023 7th International Conference on Management Engineering, Software Engineering and Service Sciences (ICMSS)*, pp. 109–114. Available at: https://api.semanticscholar.org/CorpusID:258593246.

Zhao, L. *et al.* (2022) 'A review of the innovative application of phase change materials to cold-chain logistics for agricultural product storage', *Journal of Molecular Liquids*, 365, p. 120088.