ISSN: 2338-8412 e-ISSN : 2716-4411

Ekombis Review – Jurnal Ilmiah Ekonomi dan Bisnis
Available online at : https://jurnal.unived.ac.id/index.php/er/index
DOI: https://doi.org/10.37676/ekombis.v13i4

Evaluation Of Cold Chain Awareness And Technology Adoption In Cold Chain Operations: A Descriptive Analysis

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How to Cite :
Jaelani, I., Harsanto, B., Azis, Y., Sari, D. (2025). Evaluation Of Cold Chain Awareness And Technology Adoption In Cold Chain Operations: A Descriptive Analysis. EKOMBIS REVIEW: Jurnal Ilmiah Ekonomi Dan Bisnis, 13(4). DOI: https://doi.org/10.37676/ekombis.v13i4

ARTICLE HISTORY
Received [10 May 2025]
Revised [18 September 2025]
Received [27 September 2025]

KEYWORDS
Cold Chain, Industry Awareness, Technology Adoption, Refrigerated Logistics, Quantitative Survei.

ABSTRACT

The cold chain is a critical logistics system for maintaining the quality of temperature-sensitive products such as food, pharmaceuticals, and vaccines. This study aims to evaluate industry players' awareness of the importance of cold chain and the level of technology adoption in cold chain operations. A quantitative survey method was used, distributing questionnaires to 150 respondents involved in the cold product supply chain across various sectors. The findings indicate that while 85% of respondents understand the importance of cold chain, only 60% have adopted modern technologies such as digital temperature sensors, IoT, and real-time tracking systems. The main barriers to adoption are investment costs and lack of technical training. This study highlights the importance of awareness programs, training, and incentives to encourage businesses to enhance the efficiency and reliability of the cold chain system in Indonesia. The implications of this research are expected to support the development of policies and strategies for wider implementation of technology in refrigerated logistics systems.

INTRODUCTION

In the era of globalization and increasing demand for products that require special temperature handling, the cold chain system plays a very vital role. Cold chain is not just a process of storing and shipping goods at low temperatures, but an integrated and sustainable logistics system that ensures the quality and safety of temperature-sensitive products are maintained from the point of production to the hands of consumers. Products such as fresh food, meat, dairy products, medicines, and vaccines are highly dependent on the effectiveness of the cold chain system. If there is a failure to maintain the appropriate temperature during the distribution process, it will not only cause economic losses but can also endanger consumer health. Awareness of the importance of the cold chain is a major factor in the successful implementation of this system (Affognon et al, 2019). Without a good understanding from industry players, from producers, distributors, to retailers, the implementation of the cold chain

is often not carried out optimally. Many business actors, especially in developing countries such as Indonesia, still consider the cold chain as an additional burden in logistics operations, even though this system is actually a long-term investment that can increase consumer confidence and product competitiveness. Lack of knowledge and minimal technical training are obstacles in spreading this awareness. This is exacerbated by the still limited support for infrastructure and supporting technology, especially in remote areas. On the other hand, technological advances have opened up great opportunities to improve the efficiency and reliability of the cold chain. Various innovations such as Internet of Things (IoT)-based temperature sensors, GPS-based tracking systems, and supply chain management software have proven to be able to improve control and transparency in the distribution process of cold products. However, the adoption of this technology is still relatively low among small and medium business actors. The main obstacles faced are the relatively high initial investment costs and limited human resources in operating the technology. This is where the importance of a strategic approach to encourage technology adoption lies, including through government incentives, partnerships with technology providers, and ongoing education programs. This study aims to evaluate the level of awareness of industry players regarding the importance of the cold chain system and to identify the extent to which technology has been adopted in their operational practices. Using a descriptive analysis survey approach, this study collects data from various actors in the cold product supply chain to obtain a more comprehensive picture of the challenges, obstacles, and potential for developing a cold chain system in Indonesia. The results of this study are expected to be the basis for recommendations for policy makers, technology providers, and industry players in designing strategies to improve refrigerated logistics systems that are more adaptive, efficient, and sustainable (Angin et al, 2023).

Amid the increasing need for safe and hygienic product distribution, especially after the COVID-19 pandemic, the role of the cold chain is increasingly strengthened as the backbone in ensuring the continuity and security of the supply chain. The pandemic has opened the eyes of many parties that temperature control in the distribution of medical and food products is no longer an option, but a necessity. In addition, changes in people's lifestyles that now increasingly rely on online shopping services for fresh food needs have also driven demand for logistics systems that are able to maintain product quality to consumers' doors. This condition requires all parties in the logistics ecosystem, both from the private sector and the government, to start building and strengthening adequate cold chain infrastructure.

However, building an effective cold chain system cannot be done without a deep understanding of conditions in the field, especially regarding the perceptions and readiness of industry players in adopting the latest technology. This study not only seeks to assess the level of knowledge of industry players regarding the cold chain, but also explores the factors that influence their decisions to adopt or reject supporting technology. Thus, this data-based approach is expected to provide a real contribution in accelerating digital transformation and improving the quality of refrigerated logistics systems in Indonesia.

LITERATURE REVIEW

The Cold chain is a crucial part of a modern logistics system that plays a role in maintaining a stable product temperature within a predetermined range, starting from the storage process, transportation, to final distribution. This concept is specifically designed to handle products that are very sensitive to temperature changes, such as fresh food, medicines, pharmaceutical products, and vaccines. Temperature stability is very important because the slightest fluctuation can cause a decrease in quality, contamination, and even permanent damage to the product. In this context, the cold chain is not only a technical solution, but also a guardian of product quality and safety until it reaches consumers. On the other hand, food products that are not properly maintained can rot which is not only economically detrimental

but also poses a health risk. Therefore, cold chain management must be carried out strictly with reliable temperature monitoring technology and supporting infrastructure such as cold storage, refrigerated vehicles, and an integrated tracking system. Good cold chain implementation not only ensures that product quality is maintained, but also increases consumer confidence in the brand or company concerned, because it is considered capable of providing safe, fresh, and consumable products (Mohan et al, 2023). Industry players' awareness of the importance of the cold chain system is the main key to ensuring the successful implementation of an efficient and safe supply chain, especially for temperature-sensitive products. In practice, there are still many business actors, especially from small and medium enterprises, who do not fully understand the vital role of the cold chain in maintaining product quality and safety. Many business actors still rely on traditional methods of storing and distributing products, without realizing that the risk of damage due to uncontrolled temperatures can be much greater than the cost of investing in the cold chain itself (Miljković and Winter, 2021). This low awareness also has an impact on weak compliance with the standards and regulations for product storage and distribution that have been set. As a result, the potential for product damage increases, which not only causes financial losses but can also have serious impacts on consumer health, especially for pharmaceutical and food products.

Therefore, it is important for the government, industry associations, and related institutions to encourage ongoing socialization, education, and training regarding the importance of the cold chain system. Increasing industry players' understanding of the long-term benefits of the cold chain will help create a more resilient, safe, and competitive logistics ecosystem. Adoption of technology in the cold chain system has become a strategic step in addressing the challenges of distributing temperature-sensitive products, such as frozen food, medicines, and vaccines. Technology plays a central role in ensuring that products remain within the appropriate temperature range throughout the supply chain, from production to the end consumer. One of the key innovations is the use of Internet of Things (IoT)-based temperature sensors that enable continuous temperature monitoring during storage and shipping. Data collected from these sensors is then transmitted in real-time to a cloud-based monitoring platform, providing complete visibility into the condition of the product at every point in the distribution chain.

This technology not only helps in detecting potential temperature deviations early but also enables quick intervention to prevent product damage. In addition, real-time tracking systems provide information on the location and condition of products during the journey, thus strengthening the transparency and reliability of logistics. The application of technology in the cold chain has been proven to reduce the risk of failure in the logistics process and directly increase customer satisfaction levels. However, the implementation of this technology is not without obstacles. High initial investment costs are often a major barrier, especially for small and medium-sized businesses. In addition, the limited workforce with technical skills and resistance to changes in conventional systems also pose challenges in the process of adopting technology as a whole (McKenzie et al, 2020).

The descriptive analysis survey approach in operational evaluation offers a systematic and objective framework for understanding the various dynamics in an industrial system, including in the context of the cold chain. By using instruments such as structured questionnaires, researchers can collect data from a large number of respondents representing various parts of the cold chain distribution chain, from manufacturers, distributors, to storage and retail. This approach provides advantages in terms of time efficiency and data coverage, as it allows for the collection of information on a large scale in a relatively short time. In practice, surveys can explore the extent to which cold chain actors understand the importance of automatic temperature monitoring technology, IoT-based tracking systems, or digital applications in managing product logistics that require special temperature handling. In addition, surveys can

also reveal obstacles faced in implementing technology, both in terms of costs, human resources, and infrastructure.

METHODS

This study will explore the relationship between the external environment and business performance through qualitative methods, namely case studies and stakeholder interviews. This study uses a qualitative approach with a case study method to gain an in-depth understanding of the influence of the external environment on business performance in the residential property industry in Indonesia. This approach allows researchers to comprehensively explore external factors that influence the dynamics of the property industry, including government policies, economic conditions, consumer preferences (Santoso, 2023). Data collection techniques are carried out through in-depth interviews with various stakeholders. The main participants in this study include property developers, government representatives related to housing regulations and policies, and consumers who are the target market for this industry. In addition to interviews, this study also relies on document analysis to further understand the policies that affect the property sector.

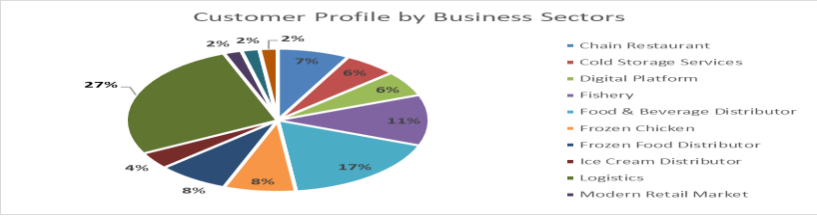
The documents analyzed include government regulations, industry reports, and market data that can provide an overview of trends and dynamics in this sector (Kabeakan et al, 2024). By combining interviews and document analysis, this study seeks to present more holistic findings. In analyzing data, this study applies triangulation techniques to ensure the validity and reliability of the findings. Triangulation was conducted by comparing interview results from various sources and confirming findings with secondary data from official documents. This approach helps reduce bias and increase the credibility of research results. With this method, it is hoped that research can provide more accurate insights into how the external environment affects business performance in the residential property industry in Indonesia, as well as how stakeholders can respond to the dynamics that occur (Jarman et al, 2023).

RESULTS AND DISCUSSION

Cold Chain Awareness

Based on the results of a survey conducted on a number of industry players who use refrigerated trucks in their operational activities, several important findings were found that reflect the level of awareness of the cold chain system and the extent to which the technology has been adopted in their logistics processes. This survey collected data from various industry sectors such as fisheries, frozen poultry, and processed foods, with a geographical coverage covering several regions in Indonesia such as West Java, Lampung, and other regions.

Figure 1 Customer Profile by Business Sectors



Most respondents have been using refrigerated trucks for more than three years, with most of them in the medium-term (3–5 years) to long-term (≥10 years) usage category. This shows that the refrigerated distribution system is not new, but has become an integral part of their business activities. However, when asked about their understanding of the cold chain concept, there are still some business actors who do not know the term specifically. This shows

that although the practice has been carried out, conceptual and theoretical understanding of the cold chain system is not yet fully distributed among industry players (Haryati et al, 2023). Cold chain is a logistics system that is very important for maintaining the quality and safety of products that are susceptible to temperature changes, such as vaccines, pharmaceutical products, and fresh food ingredients. In the modern industrial world, awareness of the importance of the cold chain is becoming increasingly crucial as the need for safe and efficient distribution of sensitive products increases. Unfortunately, in many sectors, this awareness is still uneven. Cold chain is not just about cooling, but involves a series of processes from production, storage, transportation, to final distribution, which must be controlled at a certain temperature consistently. If one link in this system is broken, the quality of the product can decrease, and can even cause major economic losses and risks to consumer health. Awareness of the cold chain is very important for industry players, especially in the food, pharmaceutical, and logistics sectors.

There are many cases where vaccines become ineffective due to storage that does not meet standard temperatures, or food is damaged because the transport vehicle does not have adequate cooling. This shows how important education and understanding of the cold chain from upstream to downstream is. Increasing awareness also includes workforce training, the use of real-time temperature monitoring technology, and the implementation of international standards such as HACCP (Hazard Analysis Critical Control Point) or GDP (Good Distribution Practice). In addition, there needs to be policies and regulations from the government that encourage companies to maintain the integrity of the cold chain for the sake of public health and product sustainability. In today's digital era, the use of IoT sensors and cloud-based tracking systems also helps increase awareness and supervision of the cold chain. With accurate and transparent data, all parties in the distribution chain can take quick action when there is a temperature deviation. In general, cold chain awareness is not only the responsibility of one party, but a collaboration between producers, distributors, regulators, and consumers. All parties must be aware that maintaining product temperature during the distribution process is an important step to ensure quality and safety. Therefore, continuous education and application of technology are the main keys to increasing awareness and effectiveness of the cold chain system as a whole. Most respondents stated that they “understand” or “very understand” the concept of cold chain and its impact on product quality. This means that there is an awareness that temperature control is a critical factor in maintaining the quality of the products being shipped. This is reinforced by the respondents' responses stating that cold chain has a major impact on the quality of the final product, especially in the context of fresh and frozen foods. However, on the other hand, there is still a gap in the application of supporting technology, such as automatic temperature monitoring, real-time tracking systems, and the use of environmentally friendly fuels (Handayani et al, 2019).

In terms of delivery frequency, most respondents make regular deliveries between two and four times per week. This shows that logistics operations are dynamic and quite active, so the existence of an efficient refrigerated system is very necessary. However, the number of refrigerated truck fleets varies quite a bit—from just a few units to dozens of units—which indicates differences in business scale and capital readiness of each company.

Table 1 Cold Chain Concept Understanding Level

No.	Cold Chain Concept Understanding Level	Total
1	Do not understand	0
2	Not really understand	0
3	Understand Enough	15
4	Understand	23
5	Very Understand	14

When delving deeper into the adoption of advanced technologies and features in refrigerated trucks, the majority of respondents admitted that they have not used environmentally friendly technologies such as alternative fuels (electricity or biodiesel), and do not consider sustainability as a primary consideration in purchasing decisions. They also stated that they do not have a specific strategy to reduce the environmental impact of truck operations, despite recognizing that refrigerated vehicles can contribute to carbon emissions. This highlights the gap between awareness of the importance of environmental quality and sustainability and real action in implementing technologies that support this (Angin et al, 2023). Interestingly, the majority of respondents stated that they have not implemented any specific quality standards or certifications for their truck fleet. Some also do not have a specific brand preference, although some respondents mentioned certain manufacturers as their primary choices. On the other hand, expectations for the service life of trucks are quite high, with most stating that they expect the vehicle to last more than 15 years. This is a challenge in itself because the long service life of vehicles needs to be accompanied by continuously updated technology to remain relevant and efficient.

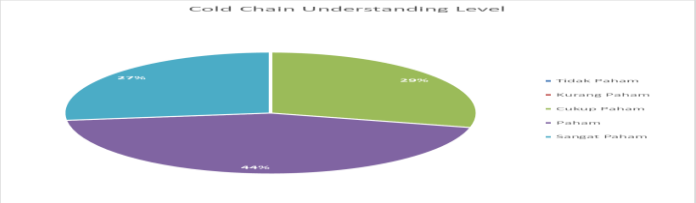
Technology Adoption

In terms of satisfaction with the performance of refrigerated trucks, most respondents were quite satisfied, but still expressed the desire for improvements in several features, especially those related to temperature stability and energy efficiency. Operational issues that are often encountered include late deliveries and technical problems with the refrigeration system. Several respondents also revealed that they have experienced product damage due to unstable temperatures during the shipping process. These challenges emphasize the importance of having a real-time temperature monitoring system and training operators and drivers to understand the importance of proper procedures in handling refrigerated products (Ahmad et al, 2023). Technology adoption is the process of accepting and implementing new technology by individuals, organizations, or the wider community in everyday life or in industrial activities. In the era of the industrial revolution 4.0, technology adoption is the main key to increasing the efficiency, productivity, and competitiveness of an entity, be it a company, government agency, or educational institution. However, this process does not always run smoothly and often requires a structured strategy. Technology adoption is not just about using new devices or digital applications, but also includes changes in work culture, system adjustments, and improving human resource competencies. For example, companies that want to switch to a digital management system must prepare infrastructure, train employees, and rearrange workflows so that the technology can be implemented optimally. One of the challenges in technology adoption is resistance to change. Many individuals or organizations feel comfortable with the old way and are reluctant to adapt to new systems that they do not fully understand. Therefore, the adoption process must be accompanied by an educational approach, ongoing training, and good communication so that the benefits of technology can be fully accepted.

In a business context, technology adoption can speed up production processes, expand market reach, and improve customer service. Technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and big data analytics are able to provide accurate and efficient data-based solutions. For example, in the logistics industry, the use of digital tracking systems and warehouse automation has been shown to significantly reduce operational costs. On the other hand, the government also has an important role in encouraging technology adoption through supportive policies, incentives, and the development of digital infrastructure. Without adequate support, the technological gap between urban and rural areas could widen. Overall, technology adoption is no longer an option, but a necessity to survive and thrive in a changing world. Organizations that are quick and precise in adopting technology will be better prepared to face future challenges, create new innovations, and provide greater added value to society and customers. Most respondents also do not have a regular maintenance contract or adequate

warranty system from the truck fleet provider. This shows that the maintenance aspect is still considered a secondary factor that is rarely prioritized. In fact, regular maintenance and after-sales service guarantees are crucial to ensure the performance of the cooling system in the long term, especially considering the high expected service life of the vehicle.

Figure 2 Cold Chain Understanding Level



In the context of technology adoption, the survey results show that digital transformation in the cold chain system is still in its early stages. Many business actors have not yet utilized technologies such as Internet of Things (IoT)-based temperature tracking systems, digital data collection, or integration with a comprehensive supply chain management system. This is both an opportunity and a challenge in driving efficiency and transparency in cold logistics in Indonesia (Affognon et al, 2015). Overall, the results of this survey indicate that awareness of the importance of cold chain has indeed grown among industry players. However, the adoption of technology and understanding of environmental sustainability still require further encouragement through education, policy incentives, and collaboration between the government, private sector, and technology providers. In the future, strengthening a sustainable and technology-based cold chain system will be key to maintaining the competitiveness of the food and health industry amidst increasingly complex global challenges.

CONCLUSION

1. Awareness of Cold Chain Most industry players already have a basic understanding of the importance of cold chain, especially in the distribution of products that require temperature control, such as food and pharmaceutical products. However, there are still disparities in the application of cold chain principles in several industrial sectors, especially in Small and Medium Enterprises (SMEs) and areas with limited infrastructure. This shows that although awareness of cold chain exists, implementation in the field is not evenly distributed.
2. Adoption of Technology Although there is an understanding of the importance of technology in supporting the cold chain system, the level of adoption of technologies such as Internet of Things (IoT)-based temperature monitoring systems, smart sensors, and supply chain management software is still relatively low. The main factors influencing the adoption of this technology are a lack of understanding of the long-term benefits, high operational costs, and limited infrastructure available in several industrial sectors.
3. Inhibiting Factors One of the main obstacles to technology adoption is the high cost of procuring and maintaining the technology, which is a burden for industry players, especially among SMEs. In addition, the lack of government policy support that can facilitate the procurement and use of cold chain technology is a challenge that cannot be ignored. Without policies that encourage investment in this technology, it will be difficult for some industry players to switch to more sophisticated solutions.

REFERENCES

Affognon, H., Mutungi, C., Sanginga, P., & Borgemeister, C. (2019). Unpacking Postharvest Losses in Sub-Saharan Africa: A Meta-Analysis. World Development. https://doi.org/10.1016/J.WORLDDEV.2014.08.002

Ahmad, F., Sibuea, E. P., Harahap, G., Sibuea, M., & Sibuea, F. A. (2023). Eksistensi Penyuluh Pertanian Dan Tingkat Adopsi Teknologi Dalam Peningkatan Produktivitas Padi Sawah di Kabupaten Deli Serdang. JASc (Journal of Agribusiness Sciences). https://doi.org/10.30596/jasc.v7i2.16475

Angin, C. P., Pakpahan, H., & Nababan, M. B. P. (2024). Technical Efficiency Analysis of Rice Farming in Deli Serdang Regency: A Data Envelopment Analysis (DEA) Approach. Jurnal Sosial Ekonomi Pertanian. https://doi.org/10.19184/jsep.v16i3.43016

Ariadi, G., Werastuti, D. N. S., & Inggarwati, K. (2024). The effect of sustainable supply chain toward sustainability performance mediated by joint efforts and sharing activities: evidence from Bali farmer groups. Measuring Business Excellence. https://doi.org/10.1108/mbe-12-2023-0195

Handayani, E., Saleh, K., & Panggabean, E. (2019). Identifikasi Potensi Komoditas Unggulan Sektor Peranian Tanaman Pangan. Jurnal Ilmiah Pertanian (JIPERTA). https://doi.org/10.31289/jiperta.v1i2.65

Haryati, N., Rayesa, N. F., Faizal, F., & Fanani, A. A. (2023). Shallot supply chain sustainability strategy in facing the Covid-19 pandemic: Case study in Malang Indonesia. THE 4TH INTERNATIONAL CONFERENCE ON LIFE SCIENCE AND TECHNOLOGY (ICoLiST). https://doi.org/10.1063/5.0107255

James, A., & Zikankuba, V. L. (2017). Postharvest management of fruits and vegetable: A potential for reducing poverty, hidden hunger and malnutrition in sub-Sahara Africa. Cogent Food & Agriculture. https://doi.org/10.1080/23311932.2017.1312052

Jarman, A., Thompson, J., McGuire, E., Reid, M., Rubsam, S., Becker, K., & Mitcham, E. (2023). Postharvest technologies for small-scale farmers in low- and middle-income countries: A call to action. Postharvest Biology and Technology. https://doi.org/10.1016/j.postharvbio.2023.112491

Kabeakan, N. T. M. B., Purba, K. F., Intan, D. R., Lubis, W., & Vionika, C. (2024). Assessing Efficiency Of Paddy Farming In Deli Serdang Regency, North Sumatra, Indonesia. Jurnal AGRISEP: Kajian Masalah Sosial Ekonomi Pertanian dan Agribisnis. https://doi.org/10.31186/jagrisep.23.02.705- 720

Khazaeli, S., Jabalameli, M., & Sahebi, H. (2023). Bi-objective model for multi-level supply chain by focusing on quality of agricultural products: a case study. Kybernetes. https://doi.org/10.1108/k-05-2022-0745

Kilelu, C., Musyoka, D. M., & Kalele, D. (2024). Unraveling smallholder food loss and value for sustainable cold chain investments: a case of horticultural value chains in Kiambu County, Kenya. Frontiers in Horticulture. https://doi.org/10.3389/fhort.2024.1474056

McKenzie, T. J., Singh-Peterson, L., & Underhill, S. (2020). Quantifying Postharvest Loss and the Implication of Market-Based Decisions: A Case Study of Two Commercial Domestic Tomato Supply Chains in Queensland, Australia. Horticulturae. https://doi.org/10.3390/HORTICULTURAE3030044

Miljković, D., & Winter-Nelson, A. (2021). Measuring postharvest loss inequality: Method and applications. Agricultural Systems. https://doi.org/10.1016/j.agsy.2020.102984

Mohan, A., Krishnan, R., Arshinder, K., Vandore, J., & Ramanathan, U. (2023). Management of Postharvest Losses and Wastages in the Indian Tomato Supply Chain—A Temperature-Controlled Storage Perspective. Sustainability. https://doi.org/10.3390/su15021331

Nashih, A. S., Widodo, K., & Ismoyowati, D. (2019). Inventory Level Analysis of Horticultural Commodities Exported by PT BSL from Central Java Indonesia to Singapore. KnE Life Sciences. https://doi.org/10.18502/KLS.V3I3.407