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# Factors Affecting Cold Chain Logistics Performance with Supply Chain Resilience as a Mediating Variable

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**ABSTRACT**

This research aims to analyze the influence of demand, quality, technology, and cold chain logistics risks on supply chain resilience and its impact on cold chain logistics performance, including the role of supply chain resilience as a mediating variable. The study employs a quantitative approach using a survey method targeting stakeholders in the cold chain logistics industry, with data analyzed through Structural Equation Modeling (SEM). The results show that demand, quality, and technology have a positive effect on supply chain resilience, whereas cold chain logistics risks have no significant effect. Supply chain resilience is proven to have a positive and significant effect on cold chain logistics performance and mediates the influence of demand, quality, and technology on performance, while mediation through the risk variable is not supported. Additionally, technology and cold chain logistics risks have a direct effect on cold chain logistics performance. These findings confirm that improving cold chain logistics performance is more effectively achieved by strengthening supply chain resilience through robust demand management, consistent quality systems, and the application of technology. This conclusion can serve as a basis for managerial decision-making and cold chain logistics policy development..

***KEYWORDS*** *Cold chain logistics, supply chain resilience, demand, quality, technology, logistics performance*



## INTRODUCTION

The cold chain logistics industry is one of the key pillars in ensuring food safety and the quality of fishery, meat, dairy, pharmaceutical, and vaccine products. Failure to maintain cold chain temperatures contributes directly to food losses, financial losses, and public health risks. Recent studies show that cold chain logistics performance is influenced by various factors, such as optimal temperature management, infrastructure quality, the level of digitalization, packaging design, and the competence of human resources operating the system (Soekirman et al., 2025). In Indonesia, the growing demand for cold chain services continues to rise in line with the expansion of modern retail, e-commerce for fresh products, and the need for a reliable vaccine distribution system. However, the availability of cold storage facilities and temperature-controlled distribution networks remains concentrated in certain regions and is not yet evenly distributed nationwide. This condition results in high product shrinkage rates and quality decline, highlighting the urgent need to systematically improve cold chain logistics performance (Abyaneh et al., 2025; Davoudi et al., 2024; Mwizerwa & Akumuntu, 2024; Pasupuleti et al., 2024).

The main challenges faced by cold chain actors extend beyond physical infrastructure limitations to include the vulnerability of supply chains to disruptions such as transportation delays, power failures, extreme weather, regulatory changes, and natural disasters. Studies on cold chain performance frameworks show that the success of cold chains depends not only on technical aspects but also on the system's capacity to maintain service quality during disruptions—for example, through capacity redundancy, real-time monitoring systems, and standardized emergency response procedures (Chermala et al., 2025). In the fishery sector, Fauzi et al.,(2019) Tri Joko Wibowo et al. (2025) Paillin et al. (2025), found that many tuna agro-industry players in Indonesia still face supply uncertainty, limited cold chain facilities at ports and production centers, and weak coordination among supply chain stakeholders. A similar phenomenon occurs in the capture fishery marketing system, which is transitioning toward a modern cooperative model in which cold chain infrastructure has become the main determinant of marketing success (Basbeth et al., 2023).

Recent literature highlights that the concept of supply chain resilience is essential in explaining how cold chains can withstand, adapt to, and quickly recover from disruptions (Hohenstein et al., 2015; Katsaliaki et al., 2022). Supply chain resilience encompasses the ability to absorb shocks, re-route logistics flows, mobilize alternative capacities, and restore service levels within a short period (Mwenda et al., 2023). Several empirical studies show that factors such as infrastructure quality, digital technology adoption, actor collaboration, and human resource competence not only directly affect logistics performance but also enhance supply chain resilience, which ultimately drives operational performance and sustainability (Altan et al., 2024; Metwally et al., 2024). However, existing research has largely focused on general manufacturing or broad supply chain contexts, without specifically examining how internal cold chain factors affect logistics performance through supply chain resilience as a mediating variable—particularly in developing countries such as Indonesia.

A number of recent cold chain studies identify key performance determinants such as temperature management, infrastructure reliability, process digitalization, and human resource competence (Chermala et al., 2025; Soekirman et al., 2025). However, relationships among these variables are often tested through direct effect models, while supply chain resilience is typically positioned as a performance outcome rather than as a mediating mechanism that links internal factors to logistics performance. From the perspective of dynamic capabilities theory and resilience theory, an organization's ability to build resilience capacities (e.g., through cold storage flexibility, information visibility, and vertical collaboration) can explain why investments in infrastructure, technology, and human resources do or do not lead to improved logistics performance. Consequently, there remains a research gap regarding whether factors influencing cold chain logistics performance operate directly or primarily through enhanced supply chain resilience (Khan & Ali, 2022; Shashi et al., 2018; Sun & Wang, 2025; Zhang & Mohammad, 2024).

The motivation of this research is to develop a more comprehensive conceptual model by integrating prior findings on cold chain performance determinants with the concept of supply chain resilience. This study extends existing literature by incorporating supply chain resilience as a mediating variable and re-examining its role, previously studied mainly in non-cold chain manufacturing sectors. Theoretically, this study contributes to developing a resilience-oriented cold chain performance model and enriches the application of dynamic capability and resilience theory in the context of cold chain logistics in developing countries. Practically, the findings are expected to provide implications for logistics companies, agro-industry players, and policymakers by identifying key factors that not only enhance operational performance but also strengthen resilience in facing disruptions.

Based on this background, the general objective of the study is to analyze and explain factors influencing cold chain logistics performance and to test the mediating role of supply chain resilience within these relationships. The results are expected to form the basis for developing more resilient and sustainable strategies for improving cold chain logistics performance.

This study examines the effects of demand, technology, quality, and cold chain logistics risks on supply chain resilience and cold chain logistics performance, while assessing the mediating role of supply chain resilience. The study aims to analyze both the direct and indirect effects among these variables. Its findings are expected to benefit company management, investors, academics, and policymakers in identifying key factors affecting cold chain logistics performance, formulating improvement strategies, enriching theoretical models, and supporting policy formulation in logistics and national food security. In this study, cold chain logistics refers to all logistics activities involving temperature-sensitive products from upstream to downstream to maintain quality and safety. Cold chain logistics performance denotes the system's success in maintaining temperature, minimizing product damage, meeting demand on time, controlling costs, and ensuring service reliability. Demand refers to market needs and capacity adjustment capabilities; Quality encompasses product and service quality management; Technology refers to the use of digital systems to support cold chain operations; cold chain logistics risks represent potential operational disruptions affecting product quality; and supply chain resilience represents the ability of the supply chain to respond to and recover from disruptions. The study's respondents are individuals engaged in cold chain logistics and supply chain management activities.

## METHOD

This study employs a quantitative approach with an explanatory and hypothesis-testing design to examine the causal relationships between Demand, Quality, Technology, and Cold Chain Logistics Risks on Supply Chain Resilience and their direct effects on Cold Chain Logistics Performance, while also testing the mediating role of Supply Chain Resilience. Using a cross-sectional field study design, primary data were collected via structured Likert-scale questionnaires distributed online to professionals involved in cold chain operations across various companies, including those in distribution, warehousing, demand planning, quality assurance, technology, and risk management. The research instrument was adapted from previous studies and validated through expert review and pilot testing. Data analysis will utilize Structural Equation Modeling (SEM) to assess both direct and indirect effects within the conceptual model.

### Data Collection Methods

This study uses primary data obtained through an online structured questionnaire using Google Form, targeting professionals involved in cold chain logistics operations across various companies. The instrument was adapted from previous research and validated through expert review to ensure content relevance and clarity. The data collection process includes screening questions to verify respondent eligibility, followed by Likert-scale measurements of demand, quality, technology, cold chain logistics risks, supply chain resilience, and performance. Systematic monitoring and follow-ups were conducted to improve response rates, after which data cleaning was performed to ensure completeness and consistency. The collected data will then undergo validity and reliability testing to confirm instrument quality before further analysis.

**Sample Withdrawal Method**

The population in this study is professional individuals who are involved or have an understanding of cold chain logistics activities in companies/organizations that run temperature-controlled supply chains, such as the distribution of fresh food products, pharmaceuticals, vaccines, and other temperature-sensitive commodities. The target population includes personnel who work in functions directly related to cold chain operations, including logistics and distribution, transportation, marketing and business, warehousing/cold storage, quality assurance/quality control, demand planning or procurement, supply chain management, and risk/operations management. The unit of analysis of this study is individual, because the measurement of variables is carried out based on respondents' perceptions and experiences of operational processes, risks, supply chain resilience, and cold chain logistics performance.

Because the population is not fully registered and spread across various companies and supply chain networks, this study uses non-probability sampling with purposive sampling techniques. This technique was chosen so that the participating respondents were completely in accordance with the needs of the research and were able to provide valid answers. The criteria for respondents set are:

a. Work in companies/organizations that carry out cold chain logistics activities (e.g. refrigerated transportation, cold storage, pharmaceutical/fresh food distribution)
b. Be directly involved or have an understanding of the cold chain process at least in one aspect such as distribution, storage, quality, technology, risk, or supply chain resilience
c. Have at least 1 year of work experience in related functions (e.g. 1 year ≥) so that the perception given is based on adequate operational experience

In the context of analysis using covariance-based Structural Equation Modeling (SEM), adequate sample sizes generally range from at least 5–10 times the number of indicators or at least 150 respondents so that the estimation of model parameters becomes more stable (Hair et al., 2019). This study has 53 indicators so conservatively requires a sample of around 265 respondents (53 indicators × 5 respondents per indicator) to 530 respondents (53 indicators × 10 respondents per indicator). Therefore, this study targets the number of respondents in the range of 265-530 respondents who meet the above criteria, so it is hoped that the results of the analysis can fairly representative the influence of variables on cold chain logistics performance.

**Data Analysis Methods**

The data that has been collected from the questionnaire will be analyzed through two main stages, namely descriptive statistics and inferential analysis. Descriptive statistics are used to provide an overview of respondent characteristics as well as response tendencies on each research indicator. The outputs presented include respondent profiles (frequency and percentage), as well as a summary of item answers (mean, standard deviation, minimum–maximum value). This stage is important to ensure the data is worthy of further analysis, including examining the completeness of the responses, the extreme response patterns, and the distribution of the answers on the Likert scale.

For inferential analysis, this study uses covariance-based Structural Equation Modeling (SEM-CB) because the research model involves several latent constructs at once, direct and indirect causal relationships (mediation), and the need to test measurement models and structural models simultaneously. SEM-CB analysis is carried out through two stages:

a. Evaluation of the measurement model (Confirmatory Factor Analysis (CFA) to test the validity and reliability of the construct
b. Evaluation of structural models to test the path coefficients between variables according to the research hypothesis

The decision to accept or reject the hypothesis is based on the standard estimate and the level of significance (p-value), with the general p-value < 0.05 indicating a significant influence. Testing of the mediation effect of Supply Chain Resilience was carried out through indirect effect analysis using a bootstrapping procedure so that it can be known whether mediation is partial or full based on the significance of indirect influence and direct influence.

Although classical assumption tests (autocorrelation, heteroscedasticity, and Chow/Hausman tests) are generally included for linear/panel regression, this study does not use panel regression or multiple linear regression as the primary method, so the test is not the focus. Instead, this study applies feasibility tests and relevant assumptions for SEM-CB, namely normality tests (univariate/multivariate), outlier tests, and multicollinearity checks between predictor constructs (e.g. through VIF or correlation between constructs) before structural testing is carried out. In addition, the feasibility of the SEM-CB model is assessed through the Goodness of Fit (GoF) indicator. The model is declared feasible if most of the fit index meets the recommended acceptance limit, so that hypothesis testing can be valid.

## RESULT AND DISCUSSION

### Data Analysis

This sub-chapter describes the results of data analysis for research on the influence of Demand, Quality, Technology, and Cold Chain Logistics Risks on Cold Chain Logistics Performance with Supply Chain Resilience as a mediating variable. The analysis is carried out through the stages of instrument quality testing, model fit tests, and direct and indirect hypothesis testing. The data analyzed amounted to 319 respondents.

Before the theoretical hypothesis test, a fit model test was first carried out for the SEM model as shown in the following figure.

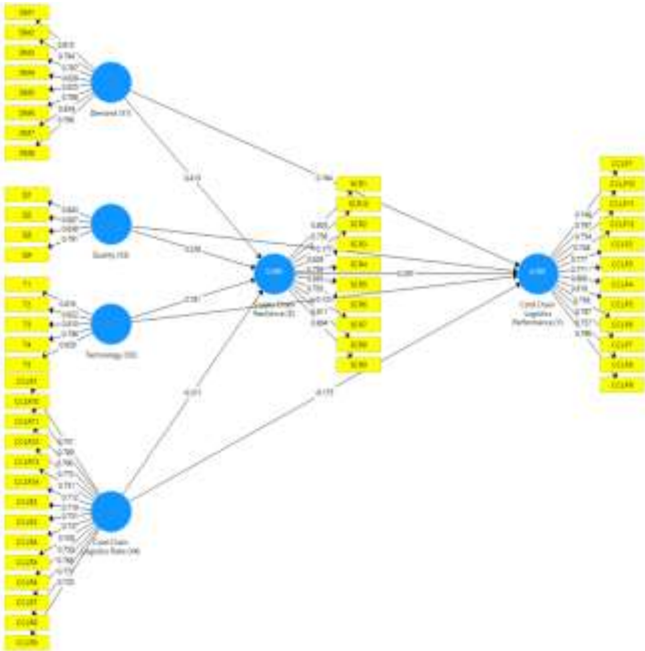

**Figure 1. SEM Research Model**

Source : Results of research data processing

The results of the fit model test in the research model used can be seen in table 4.2. Information from the table shows that from the 7 fit model criteria used, there are 2 indicators that produce fit model conclusions, namely GFI criteria and RMR criteria, while the other 7 criteria produce unfit model conclusions. Because from a number of criteria there are 2 criteria for a fit model to be met, theoretical hypothesis testing can be carried out.

**Table 1. Model suitability testing indicators**

| Measurement | Fit Model Results | Processed Results | Verdict |
|---|---|---|---|
| Chi-square | Low chi-square | 115,277 | |
| p-value | ≥ 0,05 | 0,000 | Poor fit |
| GFI | ≥ 0,90 | 0,908 | Model fit |
| RMR | ≤ 0,05 | 0,009 | Model Fit |
| RMSEA | ≤ 0,10 | 0,599 | Poor fit |
| NFI | ≥ 0,90 | 0,673 | Poor fit |
| YOUTH | ≥ 0,90 | 0,675 | Poor fit |
| CFI | ≥ 0,90 | 0,661 | Poor fit |

Source : Results of research data processing

In this sub-chapter, the results of the research will be explained which then test the hypothesis that has been carried out in the previous chapter. Hypothesis testing was carried out using the path coefficient value (β), t-statistical value, and p-value. The decision was taken using a significance level of 5% ($p \leq 0.05$) and some hypotheses were also assessed at 10% ($p \leq 0.10$) according to markers (*) and (**) on the results table.

**Table 2. Testing research hypotheses**

| Hipotesis | | Coeficin | Statistics | P-value | Decision |
|---|---|---|---|---|---|
| H1 | Demand has a positive effect on supply chain resilience | 0,337 | 7,019 | 0,000** | Hypotheses Supported |
| H2 | Quality has a positive effect on supply chain resilience | 0,081 | 3,240 | 0,001** | Hypotheses Supported |
| H3 | Technology has a positive effect on supply chain resilience | 0,051 | 1.504 | 0,066* | Hypotheses Supported |
| H4 | Cold chain logistics risks have a negative effect on supply chain resilience | 0,047 | 0,957 | 0,169 | Hypotheses not Supported |
| H5 | Demand has a positive effect on Cold Chain Logistics Performance | 0,020 | 0,397 | 0,346 | Hypotheses not Supported |
| H6 | Quality has a positive effect on Cold Chain Logistics Performance | 0,027 | 1,040 | 0,149 | Hypotheses not Supported |
| H7 | Technology has a positive effect on Cold Chain Logistics Performance | 0,108 | 3,249 | 0,0005** | Hypotheses Supported |
| H8 | Cold chain logistics risks have a positive effect on Cold Chain Logistics Performance | 0,146 | 3,008 | 0,0015** | Hypotheses Supported |
| H9a | Demand has a positive effect on Cold Chain Logistics Performance mediated by Supply chain resilience | 0,117 | 4,715 | 0,000** | Hypotheses Supported |
| H9b | Quality has a positive effect on Cold Chain Logistics Performance mediated by Supply chain resilience | 0,028 | 2,798 | 0,0051** | Hypotheses Supported |
| H9c | Technology has a positive effect on Cold Chain Logistics Performance mediated by Supply chain resilience | 0,0178 | 1,459 | 0,0721* | Hypotheses Supported |
| H9d | Cold chain logistics risks have a negative effect on Cold Chain Logistics Performance mediated by Supply chain resilience | 0.01645 | 0,948 | 0,1714 | Hypotheses Supported |
| H10 | Supply chain resilience has a positive effect on Cold Chain Logistics Performance | 0,350 | 6,372 | 0,000** | Hypotheses Supported |

Source : Results of research data processing

The following is an interpretation of the results of the research hypothesis testing:

1. Hipotesis 1

Hypothesis 1 is carried out with the aim of testing that demand has a positive impact on supply chain resilience. The processed results are shown with an estimated coefficient value of 0.337 which means that a decrease in Demand will reduce Supply chain resilience and conversely, an increase in Demand will increase Supply chain resilience. The statistical t-value of 7.019 produces a p-value of 0.000 < 0.05 which means that Ho is rejected and Ha is accepted, which means that the Demand Hypothesis has a positive impact on proven supply chain resilience.

2. Hipotesis 2

Hypothesis 2 is carried out with the aim of testing Quality to have a positive impact on supply chain resilience. The processed results are shown with an estimated coefficient value of 0.081 which means that increasing Quality will increase supply chain resilience and conversely decreasing Quality will reduce supply chain resilience. A statistical t-value of 3.240 produces a p-value of 0.001 < 0.05 which means that Ho is rejected and Ha is accepted, which means that the Quality Hypothesis has a positive impact on proven supply chain resilience.

3. Hipotesis 3

Hypothesis 3 is carried out with the aim of testing technology to have a positive impact on supply chain resilience. The processed results are shown with an estimated coefficient value of 0.051 which means that increasing technology will increase supply chain resilience and vice versa decreasing technology will reduce supply chain resilience. A statistical t-value of 1.504 produces a p-value of 0.066 > 0.05 which means that Ho is rejected and Ha is accepted, which means that the Technology Hypothesis has a positive impact on proven supply chain resilience.

4. Hipotesis 4

Hypothesis 4 is carried out with the aim of testing that cold chain logistics risks have a negative impact on supply chain resilience. The processed results are shown with an estimated coefficient value of 0.047 which means that an increase in Cold chain logistics risks will increase supply chain resilience and conversely, a decrease in Cold chain logistics risks will reduce Supply chain resilience. The value of the estimation coefficient that is not in accordance with the theory, shows that Ho is accepted so that it can be concluded that the hypothesis that Cold chain logistics risks have a negative effect on supply chain resilience is not proven.

5. Hipotesis 5

Hypothesis 5 was carried out with the aim of testing that Demand has a positive impact on Cold Chain Logistics Performance. The processed results are shown with an estimated coefficient value of 0.020 which means that increasing Demand will increase Cold Chain Logistics Performance and conversely decreasing Demand will decrease Cold Chain Logistics Performance. A statistical t-value of 0.397 produces a p-value of 0.346 > 0.05 which means that Ho is accepted, which means that the hypothesis of Demand has a negative impact on Cold Chain Logistics Performance is not proven.

6. Hipotesis 6

Hypothesis 6 is carried out with the aim of testing Quality to have a positive impact on Cold Chain Logistics Performance. The processed results are shown with an estimated coefficient value of 0.027 which means that an increase in Quality will increase Cold Chain Logistics Performance and conversely, a decrease in Quality will decrease Cold Chain Logistics Performance. A statistical t-value of 1.040 produces a p-value of 0.149 > 0.149 which means that Ho is accepted, which means that the Quality hypothesis has a positive impact on Cold Chain Logistics Performance is not proven.

7. Hipotesis 7

Hypothesis 7 is carried out with the aim of testing Technology to have a positive impact on Cold Chain Logistics Performance. The processed results are shown with an estimated coefficient value of 0.108 which means that increasing Technology will increase Cold Chain

Logistics Performance and conversely decreasing Technology will decrease Cold Chain Logistics Performance. A statistical t-value of 3.008 produces a p-value of 0.0015 < 0.05 which means that Ho is rejected and Ha is accepted, which means that the Technology Hypothesis has a positive impact on proven Cold Chain Logistics Performance.

8. Hipotesis 8

Hypothesis 8 is carried out with the aim of testing Cold chain logistics risks to have a positive impact on Cold Chain Logistics Performance. The processed results are shown with an estimated coefficient value of 0.146 which means that an increase in Cold chain logistics risks will increase Cold Chain Logistics Performance and conversely, a decrease in Cold chain logistics risks will decrease Cold Chain Logistics Performance. A statistical t-value of 3.008 produces a p-value of 0.0015 < 0.05 which means that Ho is rejected and Ha is accepted, which means that the Cold chain logistics risks hypothesis has a positive impact on Cold Chain Logistics Performance is proven.

9. Hypothesis 9a

Hypothesis 9a is carried out with the aim of testing that Demand has a positive impact on Cold Chain Logistics Performance mediated by Supply chain resilience. The processed results are shown with an estimated coefficient value of 0.117 which means that a decrease in Demand will decrease Cold Chain Logistics Performance mediated by Supply chain resilience and conversely an increase in Demand increases Cold Chain Logistics Performance mediated by Supply chain resilience. A statistical t-value of 4.715 produces a p-value of 0.000 < 0.05 which means that Ho is rejected and Ha is accepted, which means that the Demand hypothesis has a positive impact on Cold Chain Logistics Performance mediated by proven supply chain resilience.

10. Hypothesis 9b

Hypothesis 9b was carried out with the aim of testing Quality to have a positive impact on Cold Chain Logistics Performance mediated by Supply chain resilience. The processed results are shown with an estimated coefficient value of 0.028 which means that an increase in Quality will increase Cold Chain Logistics Performance mediated by Supply chain resilience and conversely a decrease in Quality will decrease Cold Chain Logistics Performance mediated by Supply chain resilience. A statistical t-value of 2.798 produces a p-value of 0.0051 < 0.05 which means that Ho is rejected and Ha is accepted, which means that the Quality Hypothesis has a positive impact on Cold Chain Logistics Performance mediated by proven supply chain resilience.

11. Hypothesis 9c

Hypothesis 9c was carried out with the aim of testing Technology to have a positive impact on Cold Chain Logistics Performance mediated by Supply chain resilience. The processed results are shown with an estimated coefficient value of 0.0178 which means that the increase in Technology will increase Cold Chain Logistics Performance mediated by Supply chain resilience and conversely the decrease in Technology will decrease Cold Chain Logistics Performance mediated by Supply chain resilience. A statistical t-value of 1.459 produces a p-value of 0.0721 < 0.10 which means that Ho is rejected and Ha is accepted, so that it can be concluded that the hypothesis that Technology has a positive impact on Cold Chain Logistics Performance mediated by proven supply chain resilience.

12. Hypothesis 9d

The 9d hypothesis was carried out with the aim of testing that Cold chain logistics risks have a positive impact on Cold Chain Logistics Performance mediated by Supply chain resilience. The processed results are shown with an estimated coefficient value of 0.01645 which means that the increase in Cold Chain Logistics Risks will increase Cold Chain Logistics Performance mediated by Supply chain resilience and conversely the decrease in Cold Chain Logistics Risks will decrease Cold Chain Logistics Performance mediated by Supply chain resilience. The value of the estimation coefficient that is not in accordance with the theory shows that the hypothesis that Cold chain logistics risks have a negative effect on Cold Chain Logistics Performance mediated by Supply chain resilience is not proven.

13. Hipotesis 10

Hypothesis 10 was carried out with the aim of testing Supply chain resilience to have a positive impact on Cold Chain Logistics Performance. The processed results are shown with an estimated coefficient value of 0.350 which means that an increase in Supply chain resilience will increase Cold Chain Logistics Performance and conversely, a decrease in Supply chain resilience will decrease Cold Chain Logistics Performance. The statistical t-value of 6.372 produces a p-value of $0.000 < 0.05$ which means that Ho is rejected and Ha is accepted, so it can be concluded that the Supply chain resilience hypothesis has a positive impact on Cold Chain Logistics Performance is proven.

**1. The Influence of Demand on Supply Chain Resilience**

In cold chains, demand is not only about "high demand", but also how the company is able to read demand patterns and align information between partners (e.g. sharing product information, production plans, and inventory levels). When demand is well managed, companies are quicker to adjust refrigerated warehouse capacity, reefer fleet scheduling, and delivery prioritization for products with limited shelf life. This is important because inaccurate demand predictions can cause overstock that leads to spoilage or understock that triggers service failure.

The results showed that demand had a positive and significant effect on supply chain resilience ($\beta = 0.337$; $p < 0.001$). This means that the better the coordination and sharing of demand information, the stronger the cold chain company's ability to adapt and recover from disruptions, such as sudden order changes, supplier delays, or unstable distribution conditions. These findings confirm that "demand information readiness" is one of the key foundations of resilience in cold chain operations.

**2. The Effect of Quality on Supply Chain Resilience**

Quality in cold chains is closely related to the fulfillment of temperature-sensitive product quality standards, because a slight deviation in temperature, handling, or distribution time can quickly degrade quality. When the quality system runs consistently, companies tend to have more disciplined and standardized processes, so that disruptions such as product breakdowns, customer complaints, or returns can be suppressed. In this context, quality helps to create "process stability" that makes the company better prepared for operational pressures.

The test results showed that quality had a positive and significant effect on supply chain resilience ($\beta = 0.081$; $p = 0.001$). This means that good quality practices not only improve product quality, but also strengthen the company's resilience in the face of disruptions, because the company has a control system that prevents service failures from escalating into more serious losses.

**3. The Influence of Technology on Supply Chain Resilience**

In the cold chain, technology acts as a neural system that helps companies detect and respond to disturbances quickly, for example with IoT/RFID for traceability, real-time temperature monitoring, and information systems for cross-functional coordination. Technology also helps companies run exception management, for example, when there is a delay, the company can immediately reroute or corrective actions before product quality drops.

The results showed that technology had a positive effect on supply chain resilience and was significant at the level of 10% ($\beta = 0.051$; $p = 0.066$). This indicates that technology does strengthen resilience, but the effect is relatively weaker than demand and quality. This condition can occur because the adoption of technology in the cold chain is often uneven or still limited to basic use, so the impact on the ability to recover from disruptions is not as strong as when technology is fully integrated in operational decision-making.

**4. The Effect of Cold Chain Logistics Risks on Supply Chain Resilience**

Logically, risks such as temperature breakdowns, delays, operational disruptions, or documentation issues should reduce resilience because they increase uncertainty and potential service failure. But in cold chain practice, not all risks automatically weaken a company's resilience, especially if the company is accustomed to dealing with risks and has minimum procedures in place to remain operational amid disruptions.

The results showed that cold chain logistics risks did not have a significant effect on supply chain resilience ($\beta = 0.047$; $p = 0.169$). This suggests that the level of risk perceived by respondents has not sufficiently explained the variation in the company's ability to recover or adapt. In other words, resilience is more shaped by internal factors that are "built" (such as demand integration, quality system, and technology), not solely by the magnitude of the risks faced.

**5. The Effect of Demand on Cold Chain Logistics Performance**

In a cold chain, well-managed demand should help improve performance through more precise distribution and stock planning, resulting in lower costs and increased service levels. However, demand information is often "input", while performance is also highly determined by field execution such as fleet readiness, SOP compliance, and cold storage reliability.

The results showed that demand did not have a significant effect on cold chain logistics performance ($\beta = 0.020$; $p = 0.346$). These findings indicate that demand improvements are not enough to drive performance improvements directly, and it is likely that demand works through indirect mechanisms, such as by strengthening resilience first, and then having an impact on performance.

**6. The Effect of Quality on Cold Chain Logistics Performance**

Quality in the cold chain is basically related to maintaining product quality during storage and distribution. In theory, good quality should lower claims, prevent quality degradation, and increase customer satisfaction, so that performance improves. However, in some companies, quality standards can be relatively homogeneous because they follow industry minimum standards, so the variation is small and the statistical effect does not look strong.

The results showed that quality did not have a significant effect on cold chain logistics performance ($\beta = 0.027$; $p = 0.149$). However, this result does not mean that quality is not important, but rather shows that quality plays a role as a supporting factor that strengthens resilience and maintains service stability, rather than as a direct driver of performance in this model.

**7. The Influence of Technology on Cold Chain Logistics Performance**

Technology in the cold chain has a very operational impact, such as temperature monitoring, position tracking, integration of transmission data, and strengthening information security. Technology helps reduce delays, improve delivery accuracy, and reduce losses as sensitive products require tight control from upstream to downstream. In the context of cold chain services, good technology is usually quick to see the impact because it directly affects the speed of response and the quality of execution.

The results showed that technology had a positive and significant effect on cold chain logistics performance ($\beta = 0.108$; $p < 0.001$). This confirms that technology investment and adoption are one of the key determinants of cold chain performance, as technology strengthens visibility, decision-making accuracy, and cost and time efficiency in the logistics process.

**8. The Effect of Cold Chain Logistics Risks on Cold Chain Logistics Performance**

Risk in the cold chain is generally considered a factor that decreases performance because it increases costs, prolongs lead times, and decreases product quality. However, under certain conditions, companies that face higher risks may have more mature operational systems (e.g. stricter SOPs, temperature controls, or governance) because they are forced to build mitigations to survive.

The results showed that cold chain logistics risks had a positive and significant effect on cold chain logistics performance ($\beta = 0.146$; $p < 0.01$). These findings can be interpreted as that companies that are exposed to higher risks tend to have stronger managerial and operational responses, so that their performance is maintained. Thus, this positive relationship is more reflective of "pressure-driven improvement", not that the risk is beneficial.

9. The Role of Supply Chain Resilience Mediation Between the Influence of Demand on Cold Chain Logistics Performance

Although demand does not have a direct effect on performance, demand has been proven to increase resilience. In the cold chain, demand coordination allows companies to more quickly adjust production, inventory, and delivery when changes or disruptions occur, so that companies are able to maintain services and reduce negative operational impacts.

The results of the mediation test showed that demand had a positive effect on performance through supply chain resilience ($\beta = 0.117$; $p < 0.001$). This confirms that the demand influence pathway is more effective when the company translates demand integration into adaptability and recovery, and that ability ultimately improves cold chain performance.

**10. The Role of Supply Chain Resilience Mediation Between the Influence of Quality on Cold Chain Logistics Performance**

Good quality strengthens resilience because it reduces process variability and reduces service failures. When the company is able to maintain quality, the company is also better prepared to overcome disturbances without causing significant quality damage. In cold chains, stable quality makes the recovery process faster because companies don't have to deal with escalation issues such as returns, claims, and damage to chain products.

The results of the mediation test showed that quality had a positive effect on performance through supply chain resilience ($\beta = 0.028$; $p < 0.01$). Thus, although the direct influence of quality on performance is not significant, its role is still evident through strengthening resilience which ultimately has an impact on cold chain performance.

**11. The Role of Supply Chain Resilience Mediation Between the Influence of Technology on Cold Chain Logistics Performance**

Technology has been proven to have a direct effect on performance, because the impact is directly felt on monitoring, tracking, and service accuracy. However, technology also has the potential to strengthen resilience if used for early detection of disruptions, exception analytics, and rapid replanning. This indirect path usually arises when technology is not only used as a record-keeping, but as a decision-making tool.

The results of the mediation test showed that technology had a positive effect on performance through supply chain resilience and was significant at 10% ($\beta \approx 0.018$; $p \approx 0.072$). This means that the mediation effect is present but weaker than the direct effect. In practical terms, these findings suggest that the improvement in cold chain performance of technology will be even greater if the technology is geared towards strengthening resilience, not just basic automation.

**12. The Role of Supply Chain Resilience Mediation Between the Influence of Cold Chain Logistics Risks on Cold Chain Logistics Performance**

Conceptually, resilience should be the main mechanism that retains the impact of risk on performance. However, in this study, risks did not have a significant effect on resilience, so the mediation pathway was not strong. This indicates that the risk affects performance more through direct channels, such as increased costs, delays, or service interruptions that are immediately visible on performance indicators.

The results of the mediation test showed that the relationship between risks and performance through resilience was not proven to be significant ($p > 0.05$). Thus, supply chain resilience is not the main mediator on this path in the research model, and the focus on improvement for risk is likely to be more appropriately directed to direct operational risk management, in addition to building resilience in general.

**13. The Effect of Supply Chain Resilience on Cold Chain Logistics Performance**

Supply chain resilience in the context of cold chain logistics describes the company's ability to maintain service continuity and recover quickly when disruptions occur, whether it comes from changes in demand, material delays, production problems, or customer complaints. In cold chain services, resilience is crucial because products are perishable and sensitive to time and temperature. When the company has high resilience, the company is better able to make quick adjustments such as changing distribution plans, increasing temporary capacity, rerouting fleets, or strengthening cross-functional coordination so that product quality is maintained and services continue to run according to targets. Thus, resilience is not only a "surviving" concept, but also an operational ability to maintain cold chain stability so that total costs, delivery accuracy, and product quality can be more consistent.

The results showed that supply chain resilience had a positive and significant effect on cold chain logistics performance ($\beta = 0.350$; $p < 0.001$). These findings mean that the higher the company's ability to respond and recover from disruptions, the better the performance of cold chain logistics is achieved, both in terms of cost efficiency, delivery accuracy, and customer needs. This relatively strong coefficient also strengthens the role of supply chain resilience as a strategic factor that "binds" various cold chain operational elements into more stable performance, because without resilience, improvements in demand, quality, and technology tend to be difficult to produce consistent performance when the logistics environment is in a dynamic and uncertain condition.

## CONCLUSION

Based on the results of data processing and hypothesis testing, this study concludes that demand, quality, technology, and cold chain logistics risks influence supply chain resilience and impact cold chain logistics performance. Supply chain resilience is proven to be a key factor that directly enhances performance and mediates the effects of demand, quality, and technology on performance. In contrast, cold chain logistics risks are not mediated by resilience and instead demonstrate a direct positive relationship with performance, indicating that increased risk awareness encourages stronger operational control. These findings imply that companies should prioritize the development of resilience as a core KPI by strengthening integrated demand management, ensuring consistent quality systems, investing in real-time monitoring and visibility technology, and implementing formal risk management mechanisms. Such measures ensure that improvements in operational factors translate effectively into better cold chain logistics performance. Theoretically, this study contributes to the literature by reaffirming the role of resilience as the primary mechanism linking operational factors to performance outcomes.

However, this study has several limitations related to sample characteristics, sampling techniques, the use of perception-based data, the cross-sectional research design, measurement validity of certain constructs, and the exclusion of variables such as human resource competence, governance, infrastructure, collaboration, and safety culture. Therefore, future research is recommended to broaden the study's context and scope, refine the sampling design, integrate subjective and objective data, adopt longitudinal or mixed-method approaches, introduce new moderator and predictor variables, and test alternative models to strengthen the robustness of the findings and deepen understanding of how supply chain resilience consistently drives cold chain logistics performance across different operational contexts.

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