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Research Article

EXTREME VULNERABILITY EVALUATION IN INTEGRATED POTATO SUPPLY CHAINS: SCOR APPROACH AND LIKELIHOOD-IMPACT MAPPING

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Abstract

This study quantifies the extreme vulnerability of the integrated potato supply chain at PT Fujitake Shouten, Nagasaki, Japan, amidst intersecting macroeconomic, demographic, and climate crises. By integrating the Supply Chain Operations Reference (SCOR) model with a Likelihood-Impact matrix, this research systematically prioritized 40 operational risk events validated through stakeholder consensus to assess the systemic fragility of fresh produce logistics. Empirical results reveal a dominant concentration of threats within the "High" and "Very High" risk categories, confirming an operational environment with a near-zero margin of error. The analysis identified a critical domino effect where rural labor shortages necessitate rough mechanical harvesting, causing physical tuber damage that accelerates metabolic respiration and spoilage during cold storage, ultimately disrupting financial liquidity and downstream retail performance. To mitigate these cascading failures, the study provides a data-driven framework where specific interventions notably precision cold-chain temperature management and visual quality controls are directly linked to risk reduction. These findings offer an actionable strategy for agribusiness entities to transition from reactive measures to proactive resilience, effectively stabilizing cash-to-cash cycles in vertically integrated supply chains.

Keywords: Extreme Vulnerability, Likelihood-Impact, Potato Agribusiness, Risk Assessment, SCOR Model

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INTRODUCTION

Supply chain management plays a fundamental role in sustaining modern agribusiness, particularly for fresh agricultural commodities characterized by high perishability, extremely short shelf-lives, and high biological sensitivity (Dhankar et al., 2026). (Bottazzi et al., 2023) emphasize that post-harvest losses in this commodity are a universal problem stemming from physical damage during harvesting and handling, as well as spoilage and moisture loss during storage. Supply chain efficiency for fresh produce demands a high degree of precision from the on-farm cultivation phase to the end consumer to prevent quality degradation and financial losses. Ahmed et al., (2025) assert that agri-food supply chains are highly susceptible to ripple effect disruptions, where even the slightest operational deviation in the upstream phase can accumulate exponentially into systemic failures ins the downstream phase (Gupta et al., 2025). This complexity escalates when an agribusiness entity operates with vertical integration, requiring it to independently control all critical control points amidst unpredictable external shocks.

Inventory management within the fresh food supply chain presents highly complex operational challenges where the margin of error is virtually nonexistent (Hazrana & Mishra, 2024). Viewed through the theoretical framework of supply chain resilience, miscalculations in inventory timing trigger a direct causal mechanism: supply-demand mismatches force perishable commodities into prolonged cold storage, which accelerates biological degradation, exponentially diminishing product marketability and inflicting massive financial losses (Qasem et al., 2023). Empirical evidence indicates that highly perishable commodities can suffer up to 30% post-harvest losses due to the dichotomy of overstocking-induced spoilage and understocking-driven market failures (Ibatullin et al., 2026). However, current literature largely overlooks how field-level supply fluctuations and demand uncertainty systematically degrade quality within fully integrated networks. For a large-scale entity like PT Fujitake Shouten, which manages extensive volumes of fresh potatoes across inter-island distribution channels, these unquantified risks pose a severe threat to operational continuity. To address this specific research gap, this study explicitly articulates the research problem by outlining a rigorous methodological approach. By integrating the Supply Chain Operations Reference (SCOR) model with Likelihood-Impact mapping, the intended contribution of this study is to systematically quantify these operational vulnerabilities and provide targeted, data-driven mitigation strategies to enhance the overall resilience of the potato supply chain. Furthermore, addressing these vulnerabilities is not merely about short-term survival; as Paredes-Rodríguez et al. (2024) assert, building structural resilience is a fundamental prerequisite for maintaining long-term supply chain sustainability and preventing economic degradation during unexpected disruptions.

In the contemporary global context, the agribusiness sector in Japan is facing unprecedented vulnerability pressures. The near-absolute reliance on imported fertilizer raw materials and fossil fuels heavily exposes the Japanese agricultural industry to global geopolitical crises and the sharp depreciation of the Yen exchange rate (Islam et al., 2025). The Japanese Ministry of Agriculture, Forestry and Fisheries reported that these external production cost spikes directly disrupt the resilience and profitability margins of farmers nationwide (MAFF, 2023). This challenge is exacerbated by a demographic crisis, namely the aging farming population, which forces the industry to shift toward forced mechanization and the utilization of foreign intern labor. Furthermore, the implementation of working hour restrictions for commercial truck drivers effective in 2024, widely known as the 2024 Logistics Crisis, is projected to significantly slash national logistics carrying capacity and threaten the smooth distribution of highly time-sensitive fresh food commodities.

The resilience of agribusiness supply chains is also currently vulnerable to the impacts of global climate change. Toromade et al. (2024) emphasize that climate anomalies such as shifts in temperature and rainfall patterns and an increase in the frequency of storms or cyclones massively disrupt distribution networks and devastate the productivity of agricultural commodity crops. This systemic vulnerability deals a particularly severe blow, especially to smallholder farmers and local workers who often lack the adaptive resources or adequate infrastructure to protect themselves from environmental degradation. Therefore, for integrated agribusiness companies, ignoring climate threat variables in supply chain management evaluations will not only conclusively threaten the continuity of raw material supply but also worsen financial resilience across the entire network from upstream to downstream.

Nagasaki Prefecture serves as a strategic potato production hub in Japan, possessing an agro-climatic advantage that allows for double planting seasons. However, the potatoes cultivated in this region exhibit high biological volatility; as supported by Rehman et al. (2026), their susceptibility to rapid post-harvest respiration and premature sprouting necessitates zero-defect operational movements to prevent exponential financial decay. PT Fujitake Shouten represents a focal entity managing a vertically integrated potato supply chain, encompassing 50 hectares of cultivation, post-harvest warehouse operations, and inter-island distribution to economic hubs in Shikoku and Osaka. Viewed through the theoretical framework of supply chain risk management, this extensive vertical integration severely amplifies the company’s exposure to systemic disruptions. The entity operates at an extreme level of vulnerability, forced to satisfy the Japanese retail market’s near-zero tolerance for visual defects while navigating the quantifiable pressures of macroeconomic inflation and the carrying-capacity reductions of the 2024 logistics crisis. Despite these severe operational implications, the precise causal mechanisms by which these multi-hazard threats degrade the performance of this specific integrated network remain unquantified. Consequently, to bridge this contextual challenge with analytical rigor, this study poses a specific research question: how do these intersecting biological, logistical, and macroeconomic vulnerabilities systematically disrupt the integrated potato supply chain, and what is their measurable risk magnitude?

Previous studies have attempted to examine risk management in potato agribusiness; however, most studies remain fragmented. Abu Hatab & Lagerkvist, (2024) investigated potato commodity risk management strategies focusing on separated actors, namely farmers, middlemen, and distributors. Amri et al. (2025) focused exclusively on risk mitigation analysis at the upstream farming level, while Mustaniroh et al. (2025) evaluated the potato supply chain specifically within the downstream processing industry for potato chips. The literature gap indicates that there has been no study comprehensively evaluating the extreme vulnerability of a fully vertically integrated supply chain in a developed country, particularly when the entity is simultaneously battered by macroeconomic crises and demographic-driven logistics disruptions. Therefore, this research is urgently needed to map the integrated supply chain activities using the Supply Chain Operations Reference (SCOR) model and evaluate its extreme vulnerability using Likelihood-Impact mapping, aiming to formulate empirical and strategically sound mitigation recommendations (Firmansyah et al., 2022).

RESEARCH METHOD

Research Design

This study utilized a mixed-methods approach with a sequential exploratory design. As explained, this design begins with extensive qualitative data collection to explore operational phenomena in their entirety, followed by the use of quantitative instruments to measure and generalize the risk profile in a structured manner. In the initial qualitative phase, data were sourced through in-depth interviews and field observations involving key supply chain stakeholders selected via purposive sampling, which were then triangulated with the company’s historical logistics records. To operationalize the complex agribusiness phenomena, these qualitative insights were systematically coded using the Supply Chain Operations Reference (SCOR) framework, categorizing specific risk events across five dimensions (Plan, Source, Make, Deliver, Return).

This step established a concrete linkage to the quantitative phase, as the qualitatively coded risk events directly informed the construction of the structured questionnaire parameters. Subsequently, the quantitative approach employed a Likelihood-Impact matrix instrument to measure, prioritize, and assess the exact probability and severity of each identified risk event. While this sequential design is robust for investigating complex supply chain risks, it inherently carries a limitation of potential subjective bias stemming from expert-based risk estimations. To ensure methodological transparency and mitigate this bias, the study rigorously triangulated the quantitative responses by integrating perspectives from multiple independent actors across the vertically integrated network.

The research was conducted directly at the main operational facilities of PT Fujitake Shouten, Co., Ltd., located at Iimori-cho, Isahaya City, Nagasaki Prefecture, Japan. The research time was focused during the main potato commodity production cycle to capture operational dynamics at peak loads. This location was determined purposively with the crucial consideration that the company represents a highly complex, vertically integrated agribusiness model, holding full control over the material flow of fresh produce from cross-island seed procurement (Hokkaido) to final marketing in southern Japan (Shikoku and Osaka).

Research Target/Subject

The subjects in this study were the definitive key actors directly involved in the integrated supply chain network of PT Fujitake Shouten. Because the actors within this specific supply chain ecosystem are predetermined and fixed, no sampling technique was utilized; instead, all the primary stakeholders were directly included to ensure comprehensive operational expertise and visibility (Obsi Gemeda et al., 2026). Internal targets included the company’s managing director, the farm operations manager (representing the Make dimension in the field), and the supervisors of the post-harvest and cold storage facilities. To ensure external validity and capture the complexity of the entire network, this study also targeted the fixed external partners, which included the specific seed suppliers from Hokkaido, the partnered logistics expedition service providers (representing the Deliver dimension), and the retail buyer representatives in the B2B market (representing the Return dimension).

Research Procedure

The research procedure was executed in two interconnected core stages. The first stage focused on mapping the upstream-to-downstream business process activities using the Supply Chain Operations Reference (SCOR) model instrument. This mapping categorizes operations into five pillar dimensions: Plan (planning), Source (material procurement), Make (on-farm production and in-house operations), Deliver (logistics distribution), and Return (return mechanism) (Depari et al., 2024). The use of the SCOR framework aims not only to dissect the physical material flows but also to evaluate the information flows across each operational dimension of the company. Precise information flow, in the form of supply chain traceability, is a key element that enables companies to detect anomalies in the delivery dimension and manage crises effectively (Razak et al., 2021). Based on this process anatomy, the second stage was conducted by identifying potential risk incidents within each SCOR dimension and compiling them into a risk assessment framework.

Instruments, and Data Collection Techniques

Primary data were gathered through a series of participatory observations and in-depth interviews with key informants to extract qualitative insights related to operational vulnerabilities. Secondary data were extracted by tracing the company's internal logistics history documents and triangulated with official reports from relevant Japanese ministries (such as MAFF and MLIT) to validate macroeconomic anomalies and labor crisis conditions. For the quantitative phase, the data collection instrument used was a structured 5-point Likert scale questionnaire distributed to operational experts and practitioners. This questionnaire was specifically designed to capture operational and information vulnerabilities at every product transit point, measuring two independent variables: the frequency level of occurrence probability (1 = Very Rare to 5 = Very Frequent) and the severity level of the impact (1 = Very Low to 5 = Very Extreme).

Data Analysis Technique

The data analysis process aims to quantify the vulnerability level of the fresh food supply chain. Considering that supply chain management involves a highly heterogeneous network of actors, a fragmented analytical approach would not be sufficient to capture potential systemic failures (Duarte et al., 2024). Therefore, the final data analysis relied on calculating the Risk Score obtained from multiplying the frequency value (Likelihood) by the impact value (Impact/Severity). The applied formula is: Risk Score = Frequency × Impact.

The resulting score values (ranging from 1 to 25) were then mapped into an evaluation quadrant matrix that dissects the handling priority scale into four levels: Low (Score 1-3), Medium (Score 4-8), High (Score 9-16), and Very High (Score 17-25) (Basuki, 2024). The interpretation of this matrix determines which risk events require emergency mitigation strategies to prevent the distribution of defective fresh products to downstream markets.

RESULTS AND DISCUSSION

Supply Chain Ecosystem Mapping Based on SCOR

Qualitative exploration confirmed that PT Fujitake Shouten operates a fresh produce supply chain system designed with a high degree of vertical integration. Mapping through the SCOR *Plan* dimension revealed that double planting schedules and harvest projections are strictly synchronized with aggregate retail contract orders, a strategy designed to optimize supply chain efficiency and maintain high order fulfillment rates ensuring >90% production continuity. However, this precision planning confronts severe regional demographic bottlenecks. To mitigate the physical limitations of an aging local farming population and prevent imminent supply disruptions, the company strategically absorbs foreign interns from Indonesia and Cambodia.

Allocated exclusively for non-mechanical manual labor, this demographic intervention serves as a critical operational buffer often sustaining a significant measurable percentage 30% of the manual harvest capacity which directly stabilizes baseline productivity and enhances immediate system resilience. Nevertheless, linking these operational decisions to the broader vulnerability assessment uncovers a critical trade-off. While the integration of foreign interns effectively mitigates short-term labor deficits, it simultaneously introduces a new structural risk within the *Plan* dimension; heavy reliance on a transient workforce exposes the upstream supply chain to external immigration and regulatory shocks, wherein any disruption in labor availability would drastically degrade harvest efficiency and trigger cascading financial losses across the network.

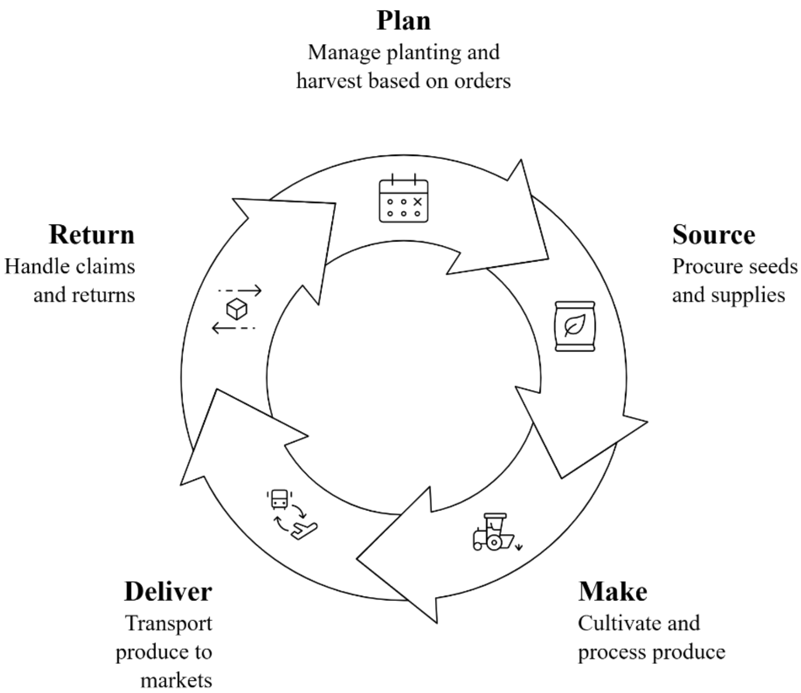

Figure 1. Supply Chain Ecosystem Mapping Based on SCOR

In the *Source* dimension, essential biological inputs such as superior *Toya*, *Danshaku*, *May Queen*, and *Kogane* variety seeds of size S are procured in ten-kilogram packages from Hokkaido Island through Diamond Tokachi Co., Ltd. Meanwhile, secondary production facility components such as fertilizers and pesticides are supplied by a local store network encompassing Tanakanoen, Chikushi Aguri, and Matsuoshi. The *Make* dimension is divided into the cultivation of 50 hectares of company-controlled land culminating in mechanical harvesting, and in-house processing where harvested potatoes enter the independent warehouse facility to undergo visual sorting, quarantine in cold storage, and the packing process. Furthermore, the *Deliver* dimension relies on partnerships with third-party expedition providers spread across Nagasaki, Ehime, and Saga to penetrate target markets in Shikoku Prefecture and metropolitan Osaka. In the terminal dimension, the *Return* protocol is prepared to respond to claims and manage the reverse flow of products from B2B customers if visual quality anomalies are detected.

Risk Matrix Evaluation and Proof of Extreme Vulnerability

Empirical evaluation through the scoring instrument successfully identified 40 specific risk events overshadowing PT Fujitake Shouten’s supply chain operations. The distribution of Risk Score values on the mapping matrix generated a threat posture classifying 4 events in the very high zone, 22 events in the high zone, 14 events in the medium zone, and zero events in the low zone.

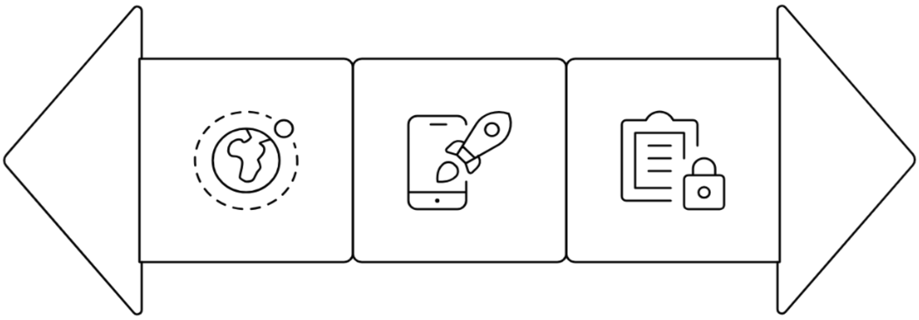

Figure 2. Risk Event Indicators Ranked By Urgency And Impact

The discovery of zero probability of low-scale risks serves as a central empirical finding that absolutely proves the theory of extreme vulnerability within the fresh agricultural commodity supply chain ecosystem. The absence of a green zone (low risk) validates the postulate by Chen et al. (2025), which asserts that the biological sensitivity of fresh commodities creates a system structure with a virtually nonexistent margin of error, where any minor technical deviation will inevitably evolve into material losses.

Table 1. Risk Evaluation in the Very High Category

Code	Risk Statement	Supply Chain Stage	F	I	Risk Score	Category
B3.R1	Drastic increase in fertilizer and pesticide prices due to Yen depreciation and global crises	Fertilizer and Medicine	5	4	**20**	**Very High**
B4.R3	Continuously rising diesel fuel prices burdening operational costs	Agricultural Machinery	5	4	**20**	**Very High**
B5.R1	Crop damage due to extreme weather (Typhoon/high rainfall)	Cultivation/On-Farm	4	5	**20**	**Very High**
B8.R1	Significant increase in logistics expedition service tariffs	Distribution	5	4	**20**	**Very High**

(Note: F = Frequency, I = Impact)

External Macroeconomic Shocks

Table 1 presents the configuration of the four most destructive risks, entirely originating from external disruption agents. The surge in fertilizer costs, the fluctuation of mechanization fuel prices, and skyrocketing expedition tariffs are direct implications of the drastic Yen depreciation pressure colliding with the global energy supply crisis. These macroeconomic shocks massively squeeze the financial endurance of Japanese agribusiness companies from both the input procurement side and the final product delivery side (MAFF, 2023). In addressing these escalating macro-level uncertainties, Wang and Wang (2026) emphasize that implementing dynamic monitoring and cross-regional coordination mechanisms is critically required to prevent structural collapse and ensure systemic resilience in national agricultural supply chains.

This systemic vulnerability is aggravated by Typhoon climate anomalies, which possess maximum severity levels due to their ability to instantaneously decimate the upstream supply foundation. The biological vulnerability of potatoes during the postharvest phase is further exacerbated by the threat of global climate change, which triggers extreme temperature fluctuations. These empirical findings are consistent with the findings of Elahi et al. (2022), who concluded that extreme weather events significantly reduce plants' biological immunity and physical integrity. Saleem et al. (2025) assert that unpredictable increases in atmospheric temperature directly affect the metabolic activity and respiration rates of agricultural products, ultimately disrupting the dormancy phase of these crops. In the case of potatoes, exposure to fluctuating temperatures due to weather anomalies can disrupt temperature stability within storage facilities (cold storage). These unstable environmental conditions force potato tubers to emerge from dormancy prematurely, triggering early sprouting and reducing the product's nutritional and visual quality before it can be distributed to the market. Therefore, the ability to precisely control the storage environment is absolutely necessary to mitigate the risk of spoilage and maintain the quality specifications of commodities amid climate uncertainty. This phenomenon aligns with the identification by Abdi et al., (2024) that macroeconomic and climate shocks are the most difficult *force majeure* disruptions to predict yet deliver the most systemic financial loss effects.

Table 2. Partial Evaluation of High Category Risks Based on the Domino Effect

Code	Risk Statement	Supply Chain Stage	F	I	Risk Score	Category
B1.R1	Shortage of skilled labor during peak harvest seasons	Labor	4	4	**16**	**High**
B6.R3	Potatoes sprout too quickly due to unstable cold storage temperatures	Warehouse	4	4	**16**	**High**
B8.R4	Difficulty obtaining truck slots during busy seasons (Truck Driver Crisis)	Distribution	4	4	**16**	**High**
B6.R1	Physical damage (bruises/cuts) to potatoes due to mechanical harvesting	Warehouse	4	3	**12**	**High**
B9.R2	Goods rejection/returns by retail parties due to visual physical defects	Marketing	3	4	**12**	**High**

Domino Effect-Based Disruption Chain

In-depth evaluation of the events in the High risk category (Table 2) uncovers the existence of a domino effect that damages operational integrity. The minimal availability of skilled labor in rural Japan (B1.R1) forces the company to substitute human labor by exploiting harvester tractor units (Shaikh et al., 2025). This cascade of operational failures is consistent with recent DEMATEL-based modeling by John et al. (2026), which confirms that acute labor shortages and forced mechanical dependencies act as primary causal factors that exponentially amplify post-harvest food waste and operational disruptions. This forced mechanization transition triggers a secondary quality crisis, where the percentage of bruises and physical damage to potato tubers drastically increases during the field extraction process (B6.R1). These findings are fully consistent with the analysis by Rehman et al. (2026), which explains that potatoes continue to respire after harvest, and that physical stress caused by mechanical impact drastically amplifies this metabolic activity, thereby breaking tuber dormancy more quickly (Tchonkouang et al., 2024). The absence of an optimization strategy at the Facility and Retailer levels will automatically multiply decay costs, thereby eroding the company's profit margins.

These mechanical wounds on the potato skin become a fatal catalyst once the products enter the cold storage facility (Nwaogu & Cherubin, 2024). Physical stress amplifies the respiration rate, causing the commodities to sprout prematurely (B6.R3) and triggering the transmission of rot. The dynamics of quality degradation due to mechanical damage have been proven to have a strong linearity with the research findings of Ramadhan et al. (2024) on fresh vegetable commodities; the study asserts that physical defects in the initial phase (such as bruises, breaks, or tears) resulting from rough harvest handling methods are the primary root causes of rotting, which directly downgrade product specifications in the market. This is fully consistent with the findings of Qasem et al. (2023), who demonstrated that excessive inventory of fresh produce not only increases cold storage costs but also directly increases the likelihood of products exceeding their shelf life, leading to physical and biological spoilage.

This upstream complication ultimately culminates in a high probability of downstream retail rejection (B9.R2) and stimulate product withdrawals by end consumers. These empirical findings are consistent with the analysis by Daneshvar et al. (2023), which demonstrates that an increase in the perishability rate of agricultural products will proportionally drive up total supply chain loss costs due to high rates of product failure. The manifestation of this ripple effect validates the theory by Gumono et al., (2024) regarding the propagative nature of disruptions in food supply chains. On the other hand, distribution paralysis caused by the difficulty in securing truck quotas (B8.R4) is a tangible manifestation of the 2024 Logistics Crisis, where government restrictions on truck driver working hours severely limit the reliability of inter-prefectural fresh commodity distribution. The negative consequences of transportation bottlenecks are evident; Nino (2025) quantified that a single road disruption reduces the volume of transported food products by 2% to 3% to the affected market, subsequently triggering local price hikes of up to 0.9% and causing a 'spillover effect' on price equilibrium in interconnected markets.

The vulnerabilities plaguing the supply chain management of fresh produce are further underscored by a study by Mohammad et al. (2025), which highlights inefficiencies in the handling of highly perishable agricultural commodities. The study confirms that the absence or weakness of adequate cold-chain infrastructure, coupled with an unstable transportation network, is the strongest independent variable driving a surge in post-harvest losses. To contextualize this risk magnitude, empirical benchmarks indicate that even minor transit temperature deviations such as a fluctuation of just 2°C to 3°C can accelerate metabolic respiration rates and increase spoilage probability by up to 20%. This demonstrates that the vulnerability of fresh produce stems not only from its inherent biological characteristics but is heavily dependent on the capabilities of the operational ecosystem. Failure to ensure strict temperature stability and careful handling practices at these critical transition points from upstream facilities to downstream retail stages drastically reduces the remaining shelf-life of the product and degrades overall market efficiency. Exponentially, this creates a domino effect of massive financial losses, which can erode retail profit margins by 5% to 15%. To build supply chain resilience and counter these systemic vulnerabilities, adopting proactive mitigation strategies such as integrating real-time IoT temperature monitoring systems and utilizing predictive logistics is critically required to safeguard product integrity and optimize overall cost performance. Furthermore, as observed by Ariadi et al. (2025) in their analysis of potato market structures, agricultural producers operating within highly concentrated or oligopolistic retail networks often act merely as price takers; therefore, they lack the bargaining power to absorb these financial losses, deeply exacerbating their vulnerability to downstream product rejections.

The operational vulnerabilities identified at PT Fujitake Shouten's packaging and storage facilities align with recent literature findings regarding agribusiness supply chain performance. In their extensive study, Wirda et al. (2025) concluded that failure to maintain reliability and quality throughout the operational process is the primary driver of high levels of waste and damage to fresh food commodities. In this case, such reliability failures manifest as a domino effect; where rough mechanical handling in the upstream phase (Make) directly causes physical damage and accelerates potato spoilage in the cold storage. This phenomenon demonstrates that micro-technical weaknesses at a single point in the SCOR framework can have systemic impacts on financial losses resulting from product rejection or returns in the downstream phases (Deliver and Return). Inefficiencies in the agricultural supply chain—such as long waiting times in warehouses or delays in transactions can drastically extend the cash-to-cash cycle time. In this case, potatoes that suffer mechanical damage from harvesters not only result in sunk costs from the production phase but also force the company's capital to remain tied up for longer in the form of illiquid inventory.

The importance of implementing risk management in the post-harvest phase is also closely tied to the obligation to meet food safety standards and ensure the highest product quality. Awuchi (2023) emphasizes that failure to identify Critical Control Points throughout the handling process of fresh produce can have fatal consequences, as physical defects allowed to slip through the production line become breeding grounds for biological and chemical contamination, such as the formation of natural toxins (Mbiafeu et al., 2024). In a post-harvest ecosystem vulnerable to human error such as worker negligence during product sorting the implementation of strict visual quality control systems and traceability systems becomes crucial (Meena et al., 2024). A transparent traceability system not only enables rapid identification of the origin of damaged products but also strengthens supply chain resilience by preventing substandard or contaminated products from being distributed to retailers.

Conversely, the analysis of the Medium category represents more isolated micro-technical vulnerabilities, such as label printing errors or manual sorting negligence by interns. Although the frequency of these events is detected, their financial loss impacts are successfully mitigated because these anomalies are identified early through multi-layered visual inspections and immediately corrected (reworked) on the production floor before the products are distributed.

CONCLUSION

This study conclusively demonstrates the extreme vulnerability inherent in the vertically integrated fresh potato supply chain at PT Fujitake Shouten. By employing the SCOR model and Likelihood-Impact mapping, 40 risk events were identified, notably with zero risks falling into the low-level category. This empirically proves that the fresh agricultural supply chain operates with a near-zero margin of error, where even minor technical deviations inevitably escalate into material and financial losses.

The evaluation reveals that the supply chain is heavily battered by uncontrollable external macroeconomic shocks specifically the depreciation of the Yen, global energy crises, the 2024 Japanese logistics crisis, and extreme climate anomalies (typhoons) which occupy the highest threat levels (Very High). Internally, the system is severely compromised by a destructive domino effect triggered by the rural demographic crisis. The acute shortage of skilled labor has forced the premature adoption of rough mechanical harvesting, which inflicts physical damage and bruises on the potato tubers. This mechanical stress drastically accelerates metabolic respiration, premature sprouting, and rotting during cold storage quarantine, which ultimately culminates in massive product rejections by strict Japanese retail markets and disrupts the company's financial liquidity.

To build resilience and break this chain of cascading failures, agribusiness entities cannot rely solely on conventional management. Companies must proactively implement strict visual quality controls at the transition points, optimize cold-chain temperature stability, and adopt transparent supply chain traceability systems. These measures are essential to isolate damaged product batches early, optimize the inventory cycle, and mitigate massive financial losses before the commodities reach the downstream market.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work the author(s) used Google Gemini in order to translate the manuscript into academic English, structure the flow of the article, and refine grammatical accuracy. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

Author 4: Formal analysis; Methodology; Writing - original draft.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Abdi, A. H., Mohamed, A. A., & Mohamed, F. H. (2024). Enhancing food security in sub-Saharan Africa: Investigating the role of environmental degradation, food prices, and institutional quality. *Journal of Agriculture and Food Research*, *17*, 101241. https://doi.org/10.1016/j.jafr.2024.101241

Abu Hatab, A., & Lagerkvist, C.-J. (2024). Perceived business risks and observed impacts of the Russian-Ukraine war among small- and medium-sized agri-food value chain enterprises in Egypt. *Transforming Global Agri-Food Value Chains*, *127*, 102712. https://doi.org/10.1016/j.foodpol.2024.102712

Ahmed, J. M., Haji, J., Jaleta, M., & Jemal, K. (2025). Drought and consumption impacts of climate-smart-agricultural practices adoption in drought prone area of Eastern Hararghe, Ethiopia. *Agricultural Water Management*, *318*, 109681. https://doi.org/10.1016/j.agwat.2025.109681

Amri, A. A., Leo, P. J. F. F., Rosada, I., & Hasan, I. (2025). Analisis Mitigasi Risiko Usahatani Kentang Dengan Metode House of Risk (Hor). *Wiratani: Jurnal Ilmiah Agribisnis*, *8*(1), 30. https://doi.org/10.33096/wiratani.v8i1.534

Ariadi, B. Y., Mazwan, M. Z., Amir, N. O., Shodiq, W. M., & Baroh, I. (2025). Analyzing the potato market in Malang Raya: Insights from the Structure-Conduct-Performance (SCP) approach. BIO Web of Conferences, 201, 03002. https://doi.org/10.1051/bioconf/202520103002

Awuchi, C. G. (2023). HACCP, quality, and food safety management in food and agricultural systems. *Cogent Food and Agriculture*, *9*(1). https://doi.org/10.1080/23311932.2023.2176280

Bottazzi, P., Seck, S. M., Niang, M., & Moser, S. (2023). Beyond motivations: A framework unraveling the systemic barriers to organic farming adoption in northern Senegal. *Journal of Rural Studies*, *104*, 103158. https://doi.org/10.1016/j.jrurstud.2023.103158

Chen, Q., Li, C., Lu, L., Ke, Y., Kang, K., Mao, S., & Liao, Z. (2025). Optimization of Fresh Produce Supply Chain Resilience Capacity: An Extension Strategy Generation Method. *Symmetry*, *17*(2), 1–35. https://doi.org/10.3390/sym17020272

Daneshvar, A., Radfar, R., Ghasemi, P., Bayanati, M., & Pourghader Chobar, A. (2023). Design of an Optimal Robust Possibilistic Model in the Distribution Chain Network of Agricultural Products with High Perishability under Uncertainty. *Sustainability (Switzerland)*, *15*(15). https://doi.org/10.3390/su151511669

Dhankar, N., Routroy, S., & Sharma, S. Kr. (2026). A multiple regression model to analyze the impact of endogenous factors on pearl millet and stover yield in India. *Journal of Modelling in Management*, *21*(2), 584–612. https://doi.org/10.1108/JM2-06-2024-0203

Elahi, E., Khalid, Z., Tauni, M. Z., Zhang, H., & Lirong, X. (2022). Extreme weather events risk to crop-production and the adaptation of innovative management strategies to mitigate the risk: A retrospective survey of rural Punjab, Pakistan. *Technovation*, *117*(January), 102255. https://doi.org/10.1016/j.technovation.2021.102255

Firmansyah, F., Mukson, M., & Prastiwi, W. D. (2022). Analisis Risiko Produksi Bunga Krisan Di P4S/ Mitra Veteran Mandiri Bandungan Kabupaten Semarang. *Ziraa'Ah Majalah Ilmiah Pertanian*, *47*(3), 354. https://doi.org/10.31602/zmip.v47i3.8002

Gailan Qasem, A., Aqlan, F., Shamsan, A., & Alhendi, M. (2023). A simulation-optimisation approach for production control strategies in perishable food supply chains. *Journal of Simulation*, *17*(2), 211–227. https://doi.org/10.1080/17477778.2021.1991850

Gumono, A., Senjawati, N. D., & Etikarini, W. D. (2024). Risk Management of Raw Material Procurement in Madukismo Sugar Factory With the House of Risk Method. *Agrisocionomics: Jurnal Sosial Ekonomi Pertanian*, *8*(3), 725–739. https://doi.org/10.14710/agrisocionomics.v8i3.21007

Gupta, S., Mishra, A. K., Mishra, S., Sen Gupta, G., Madheshiya, P., & Tiwari, S. (2025). 17—Agrochemicals: Harmful and beneficial effects of climate change scenarios. In A. Kumar, O. O. Babalola, J. S. Panwar, & G. Santoyo (Eds.), *Climate Change and Agricultural Ecosystems (Second Edition)* (pp. 399–433). Woodhead Publishing. https://doi.org/10.1016/B978-0-443-26520-4.00023-8

Habib ur Rehman, Nadia Jabeen, Tahira Batool Qaisrani, Muhammad Sufyan, Muhammad Zia ur Rahman, Andleeb Zahra, Saqib Saleem, H. A. (2026). Role of Post-Harvest Management and Value Addition in Preserving Potato Quality and Supporting

Sustainable Processing Habib. *Planta Animalia*, *5*(2), 87–100. https://doi.org/10.71454/PA.005.02.0370

Hazrana, J., & Mishra, A. K. (2024). Effect of input subsidies and extension services: Evidence from rice productivity in Bangladesh. *Food Policy*, *125*, 102628. https://doi.org/10.1016/j.foodpol.2024.102628

Ibatullin, S., Dorosh, Y., Sakal, O., Krupin, V., & Tsybulska, J. (2026). Land concentration, market regulation, and rural development: Rethinking agricultural land governance in Ukraine. *Land Use Policy*, *168*, 108065. https://doi.org/10.1016/j.landusepol.2026.108065

Islam, Md. M., Roy, K., Goswami, R., Rahman, M. C., Ara Begum, M. E., Mallick, S., Chowdhury, A., Mainuddin, M., & Monjardino, M. (2025). Farm diversification in the salt-affected coastal region of the Ganges Delta: Drivers and pathways to smallholder resilience. *Environmental and Sustainability Indicators*, *28*, 100997. https://doi.org/10.1016/j.indic.2025.100997

John, A., Verma, V. K., Gupta, S., & Jagtap, S. (2026). Enhancing perishable food supply chain resilience through digitalisation: A DEMATEL-based analysis of key disruptions and technological interventions. Journal of Agriculture and Food Research, 29, 103026. https://doi.org/10.1016/j.jafr.2026.103026

Mbiafeu, M. F., Molua, E. L., Sotamenou, J., & Ndip, F. E. (2024). Investigating smallholder farmers' practical experiences, perceptions and response to climate change: An empirical analysis in Cameroon. *Food and Humanity*, *3*, 100345. https://doi.org/10.1016/j.foohum.2024.100345

Meena, R. S., Lal, R., Kumar, S., Pradhan, G., Srinivasarao, Ch., Singh, A. K., Pathak, H., Abhilash, P. C., Kumar, A., Sharma, S. K., Jat, M. L., & Singh, S. (2024). Chapter Two—Potential of Indian agriculture for capturing atmospheric CO2 and monetizing carbon credits to the farmers: An overview and policy framework. In D. L. Sparks (Ed.), *Advances in Agronomy* (Vol. 188, pp. 101–206). Academic Press. https://doi.org/10.1016/bs.agron.2024.06.001

Mohammad, A. A. S., Mohammad, S. I. S., Al-Daou, K. I., Oraini, B. Al, Vasudevan, A., & Feng, Z. (2025). Optimizing the Value Chain for Perishable Agricultural Commodities: A Strategic Approach for Jordan. *Research on World Agricultural Economy*, *6*(1), 465–478. https://doi.org/10.36956/rwae.v6i1.1571

Mustaniroh, S. A., Sucipto, S., Pujiastuti, Y., Prabaningtias, N., Saputri, P. R., Koentjoro, M. P., & Rahma, R. A. (2025). Enhancing the Halal Potato Chips Supply Chain: Innovative Risk Mitigation Strategies for Sustainable Growth. *Eastern-European Journal of Enterprise Technologies*, *1*(13(133)), 17–26. https://doi.org/10.15587/1729-4061.2025.316197

Nino, G. (2025). *Disruption in ground transportation: Landslides and disintegration of local food markets* [Working Paper]. SSRN. https://doi.org/10.2139/ssrn.5028042

Nwaogu, C., & Cherubin, M. R. (2024). Chapter One—Integrated agricultural systems: The 21st century nature-based solution for resolving the global FEEES challenges. In D. L. Sparks (Ed.), *Advances in Agronomy* (Vol. 185, pp. 1–73). Academic Press. https://doi.org/10.1016/bs.agron.2024.02.003

Obsi Gemeda, D., Mosissa Ejeta, T., Biftu Jabana, G., Kedir Alo, Z., Bekele, Y., Hailemariam Mamo, M., Makonene Kumsa, D., Dereje Mekonen, L., Abeshu Disassa, G., Edilu Tufa, G., Benti Chalchissa, F., Wakgari Bortola, G., Amanuel Dufera, J., Fufa Eticha, S., Niguse Dejene, I., Girma, T., Wagari, M., Habtamu Nemera, A., Tamiru, H., … Badasa Moisa, M. (2026). Impacts of climate change on water resources and farming community adaptation strategies in southwestern Ethiopia. *Environmental and Sustainability Indicators*, *30*, 101207. https://doi.org/10.1016/j.indic.2026.101207

Paredes-Rodríguez, A. M., Orejuela-Cabrera, J. P., & Osorio-Gómez, J. C. (2024). Integrating sustainability and resilience in agri-food supply chains. International Journal of Sustainable Engineering, 17(1), 1122–1138. https://doi.org/10.1080/19397038.2024.2430514

Razak, G. M., Hendry, L. C., & Stevenson, M. (2023). Supply chain traceability: a review of the benefits and its relationship with supply chain resilience. *Production Planning and Control*, *34*(11), 1114–1134. https://doi.org/10.1080/09537287.2021.1983661

Saleem, A., Anwar, S., Nawaz, T., Fahad, S., Saud, S., Ur Rahman, T., Khan, M. N. R., & Nawaz, T. (2025). Securing a sustainable future: the climate change threat to agriculture, food security, and sustainable development goals. *Journal of Umm Al-Qura University for Applied Sciences*, *11*(3), 595–611. https://doi.org/10.1007/s43994-024-00177-3

Sembiring Depari, M. M., Roessali, W., & Kusmiyati, F. (2024). Analysis of Potato Supply Chain Management in Ngablak and Pakis Districts, Magelang Regency. *Agrisocionomics: Jurnal Sosial Ekonomi Pertanian*, *8*(3), 842–864. https://doi.org/10.14710/agrisocionomics.v8i3.22025

Shaikh, T. A., Rasool, T., & Mir, W. A. (2025). Fields of the future: Digital transformation in smart agriculture with large language models and generative AI. *Computer Standards & Interfaces*, *94*, 104005. https://doi.org/10.1016/j.csi.2025.104005

Tchonkouang, R. D., Onyeaka, H., & Nkoutchou, H. (2024). Assessing the vulnerability of food supply chains to climate change-induced disruptions. *Science of The Total Environment*, *920*, 171047. https://doi.org/10.1016/j.scitotenv.2024.171047

Wang, H., & Wang, Z. (2026). Measurement, regional disparity decomposition, and evolutionary convergence of China's agricultural product supply chain resilience: A multi-dimensional empirical study. Systems, 14(6), 648. https://doi.org/10.3390/systems14060648

Wirda, B., Irwandi, P., Muflikh, Y. N., & Nurmalina, R. (2025). The use of supply chain operations reference (SCOR) in measuring the performance of supply chain management in agribusiness sector. *Agromix*, *16*(1), 71–91. https://doi.org/10.35891/agx.v16i1.5742