Ensuring a Sustainable Supply Chain: Retailers' Response to Food Supply Chain Disruptions Through the Integrated Supply Chain Resilience and Adaptation (ISCRA) Framework

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ABSTRACT

The COVID-19 pandemic has significantly disrupted global supply chains, with the retail food sector being one of the most affected. In Malaysia, challenges such as labor shortages, transportation restrictions, and fluctuating consumer demand have exposed vulnerabilities in the food supply chain. This study proposes the Integrated Supply Chain Resilience and Adaptation (ISCRA) Framework to enhance supply chain sustainability and resilience. By integrating Supply Chain Resilience Theory, Disruption Management Theory, Resource-Based View (RBV) Theory, and Systems Theory, the ISCRA Framework provides a holistic approach to mitigating disruptions. The study utilizes secondary data and predictive analytics, employing linear regression and CART decision tree models to assess disruption factors and recommend strategic interventions. Findings highlight the need for digital transformation, diversified sourcing strategies, and enhanced inventory management to ensure supply chain sustainability. This research contributes to supply chain management literature and offers practical insights for policymakers and industry stakeholders in strengthening food security and resilience against future disruptions.

Keywords: Supply Chain Resilience, Disruption Management, Predictive Analytics, Sustainable Supply Chain, Food Security

INTRODUCTION

The COVID-19 pandemic has severely disrupted global supply chains, with the retail food sector among the hardest hit. This sector is essential for food security and economic stability, especially in Malaysia, which relies on both domestic production and food imports. The crisis exposed major weaknesses in Malaysia’s food

supply chain, including movement control orders (MCOs), labor shortages, transport restrictions, and shifts in consumer demand, highlighting a lack of resilience in supply chain management (Ali et al., 2022; Chowdhury et al., 2021). Malaysia's retail food supply chain involves farmers, producers, distributors, and retailers, all playing a crucial role in feeding over 32 million people. The sudden enforcement of MCOs in March 2020 led to panic buying, stock shortages, and delays in food distribution, exposing vulnerabilities such as over-reliance on imports, poor inventory management, and limited use of digital technologies (Ivanov, 2020; Dubey et al., 2021).

The disruptions have impacted both supply and demand. Cross-border restrictions and labor shortages have slowed production and distribution, while changing consumer behavior has increased demand for online grocery shopping and home delivery. The perishable nature of food adds further complexity, requiring efficient logistics and cold chain management to prevent spoilage and reduce waste (Chowdhury et al., 2021; Ali et al., 2022). In response, the food retail industry has begun adopting digital technologies such as e-commerce, predictive analytics, and automation to strengthen supply chain resilience. However, Malaysia's progress in implementing these innovations has been slow, presenting opportunities for further research and practice (Dubey et al., 2021; Ivanov, 2020).

This study examines the impact of COVID-19 on Malaysia's retail food supply chain, identifying key challenges and potential solutions. Using a case study approach, it aims to provide insights into strengthening supply chain resilience. The findings contribute to the broader literature on pandemic-related disruptions and offer practical guidance for policymakers, industry leaders, and researchers.

Background

The COVID-19 pandemic significantly disrupted global supply chains, particularly the retail food sector, which relies on fast deliveries, perishable goods, and complex logistics. Lockdowns, border closures, and labor shortages led to transportation delays, while panic buying created supply and demand imbalances, further straining the system. Many businesses worldwide turned to digital solutions like predictive analytics, blockchain, and automation to improve efficiency, but Malaysia struggled to adopt these technologies due to infrastructure and resource limitations. The country's food supply chain was already heavily dependent on imports, and although government policies aimed to strengthen domestic production, they did not account for sudden disruptions like a pandemic.

In Malaysia, Movement Control Orders (MCOs) in March 2020 disrupted food distribution, causing shortages and import delays. Labor shortages further impacted food production and transportation, while online grocery shopping surged by 200%, leaving many small retailers unable to adapt. To build a resilient supply chain, businesses must embrace digital tools, diversify suppliers, and collaborate with stakeholders. However, research on COVID-19's specific impact on Malaysia's retail food sector remains limited, with most studies focusing on broader economic effects. This study aims to address these gaps by analyzing supply chain disruptions, assessing mitigation strategies, and providing recommendations to enhance resilience and food security.

Problem Statement

The COVID-19 pandemic has severely impacted global supply chains, with Malaysia's retail food supply chain being one of the hardest hit. Movement Control Orders (MCOs), labor shortages, transportation issues, and changing consumer demand have caused food shortages, price fluctuations, and reduced food security (Ali et al., 2022; Chowdhury et al., 2021). Despite its importance, there is little research on what specifically caused these disruptions and how well different solutions have worked.

Most studies focus on the broader economic impact of the pandemic, such as GDP decline and trade disruptions, rather than the real challenges faced by businesses in the supply chain. There is also limited data on how disruptions occur at different levels of the supply chain. While digital tools like predictive analytics and blockchain can help strengthen supply chains, Malaysia has been slow to adopt them due to infrastructure challenges, high costs, and a lack of expertise (Dubey et al., 2021; Ivanov, 2020).

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This study aims to fill these gaps by analyzing the main causes of supply chain disruptions in Malaysia. It will: (1) identify key disruption factors, (2) evaluate the effectiveness of current logistics models, and (3) develop a machine learning-based predictive analytics tool to improve supply chain resilience. By providing data-driven insights, this research will help policymakers, businesses, and researchers develop better strategies to prevent future disruptions.

Hypothesis

This study is guided by the following hypotheses, which align with the research objectives and aim to explore the impact of the COVID-19 pandemic on Malaysia's retail food supply chain:

a) Hypothesis 1: The Malaysian retail food supply chain was significantly disrupted by pandemic-related challenges, including labor shortages, transportation restrictions, and shifts in consumer demand.

b) Hypothesis 2: The existing logistics model in Malaysia's retail food supply chain lacks the efficiency and resilience needed to handle disruptions like COVID-19, highlighting the need for improved strategies to enhance recovery capabilities.

c) Hypothesis 3: Predictive analytics, particularly using linear regression and CART decision tree machine learning techniques, can strengthen the supply chain by forecasting disruptions and enabling better decision-making for future crises.

Research Objectives

This study aims to analyze the impact of the COVID-19 pandemic on Malaysia's retail food supply chain, focusing on the current logistics model, disruption drivers, and the development of predictive tools for improved resilience. The research is guided by the following objectives:

1. To identify pandemic-related variables and challenges that significantly disrupted the Malaysian retail food supply chain.
2. To evaluate the current logistics model and propose optimized strategies to enhance the resilience of the supply chain.
3. To develop a machine learning model using secondary data to predict supply chain disruptions and support decision-making in the retail food industry.

Research Questions

The study addresses the following research questions, which are derived from the objectives:

1. What pandemic-related factors had the most significant impact on Malaysia's retail food supply chain?

2. What are the limitations of the current logistics model, and what strategies can improve its resilience?

3. Which machine learning algorithm is most effective in predicting disruptions in Malaysia's retail food supply chain using secondary data?

Significance of the Study

This study contributes to both academic research and practical applications in Malaysia's retail food supply chain. Its key contributions include:

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CONTRIBUTION TO LITERATURE

The COVID-19 pandemic has disrupted global supply chains, but there is little research on how it has affected Malaysia's retail food sector. This study fills that gap by identifying key challenges, causes of disruptions, and the effectiveness of existing preventive measures.

1. Practical Implications for Policymakers and Industry

The findings will help policymakers and industry leaders understand supply chain disruptions and develop strategies to improve food security, prevent future disruptions, and strengthen resilience in Malaysia.

2. Improving Supply Chain Management

By exploring the use of machine learning for predicting supply chain disruptions, this study provides retailers and suppliers with tools to anticipate and respond to challenges more effectively.

3. Support for Future Research

This study highlights gaps in current research on digital tools, machine learning, and supply chain resilience. It will serve as a foundation for future studies on the long-term effects of the pandemic and the role of digital technologies in building resilient supply chains.

Limitations of the Study

Despite its contributions, this study has several limitations:

a) Limited Data Scope

The study relies mainly on secondary data from reports and government databases. While reliable, these sources may not fully capture real-time disruptions or reflect the perspectives of key stakeholders such as retailers, producers, and distributors.

b) Geographic Focus

Since this study focuses on Malaysia, its findings may not apply to other countries or regions with different supply chain dynamics.

c) Barriers to Technology Adoption

While the study explores digital technologies like machine learning for supply chain resilience, Malaysia's limited infrastructure and resources may slow down their adoption, affecting their practical application.

d) Time Constraints

This study examines disruptions during a specific period of the pandemic. Since the long-term effects of COVID-19 on supply chains are still evolving, future research will be needed to track ongoing changes and mitigation strategies.

e) Predictive Model Limitations

The machine learning model developed in this study is based on secondary data, which may have gaps or inaccuracies. The model's accuracy will improve over time as more data becomes available.

LITERATURE REVIEW

The COVID-19 pandemic has underscored the fragility of global supply chains, particularly in the retail food sector, which is critical to ensuring food security and economic stability. This literature review examines the key variables and themes relevant to the research objectives, including pandemic-related disruptions, supply

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chain resilience, logistics optimization, and predictive analytics in the context of the Malaysian retail food supply chain.

Pandemic-Related Disruptions in the Retail Food Supply Chain

After the COVID-19 pandemic, there were major supply chain disruptions across the globe, especially in the retail food sector. A combination of travel restrictions, labour shortages, and changing consumer demand exposed vulnerabilities in the global supply chain network. In Malaysia, for example, the Movement Control Order (MCO) was implemented while international trade was disrupted, naturally imposing more practical constraints on the inflow and outflow of goods and discussing shortages in outlet outlets (Ali et al., 2022).

In this section, it consists of:

a) Outline the key factors of retail food supply chain disruptions due to the COVID-19 pandemic.

b) Present both sides of the debate, the causes of and the impacts on these disruptions.

c) Investigate the challenges, including the impact on food security and the economy of the disruptions to the Malaysian in retail food supply chain.

This section seeks to clarify how these elements crystallized the difficulties experienced by the Malaysian retail food supply chain during the pandemic period.

Transportation Restrictions and Logistics Challenges

The most direct consequence of the pandemic was on transportation and logistics, which had stopped the movement of goods not only across borders but also between them. The MCOs were imposed in Malaysia since March 2020 that restricted the movement of people and goods (Ali et al., 2022) and resulted in delayed delivery of food products and shortages in the retail outlets. This challenge was compounded by the fact that many food items are perishable, meaning that delays in transportation meant that food simply spoiled and wasted (Ivanov, 2020). The redirection of exports to other countries when borders were recently closed led to halts in the importation of essential foods in Malaysia such as rice, wheat, and dairy (Department of Statistics Malaysia, 2020). Transportation restrictions were necessary to contain the spread of COVID-19 and safeguard public health. These measures were essential to prevent an overwhelmed healthcare system that can lead to catastrophic societal and economic consequences (Chowdhury et al., 2021). Even though transportation restrictions were needed, but they were enacted without even thinking about how they would affect supply chains. A more organised approach need to implement— for instance, by creating “green lanes” for essential goods—would have been able to both reduce disruptions while addressing public health concerns (Dubey et al., 2021).

Labor Shortages and Production Disruptions

The pandemic also created major labour shortages, as the quarantine measures which limits on cross-border movement. Representatives from the agricultural and food sectors in Malaysia have stressed the importance of foreign labour in both production and distribution and a large portion of the retail food supply chain relies heavily on foreign workers. This labour force became unattainable due to the MCOs and border closures, attributing to production and distribution delays (Ministry of International Trade and Industry, 2021). For example, the palm oil industry, one of the leading components in Malaysia's food exports, experienced acute labour shortages which resulted in a 30 percent decline in production and export (Nielsen, 2020).

Labor shortages were simply a byproduct of a pandemic that caused governments to prioritize public health over economic activity. Such actions were needed to avoid the collapse of health systems and to protect vulnerable groups (Ivanov, 2020). Foreign labor dependency revealed a systemic weakness in Malaysia's retail food supply chain. However, the reliance on foreign labor could have been curtailed with more investment in automation and local workforce development (Ali et al., 2022).

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Fluctuating Consumer Demand and Panic Buying

Aside from panic buying and stockpiling, the pandemic caused a sudden volatility in demand and put supply chains under stress. For instance, as governments in Malaysia imposed MCOs suddenly, consumers exhibited panic buying behaviour, leading to shortages of food essentials like rice, canned goods, and cooking oil, as well as price volatility (Chowdhury et al., 2021). Retailers had a hard time restocking fast enough to satisfy the surge in demand, exposing inefficiencies with inventory management and distribution networks.

Panic buying was a normal response to uncertainty and fear during a pandemic. (Dubey et al. 2021) consumers were worried about shortages and wanted to be sure they had enough supplies to survive through the lockdowns. While panic buying was natural behaviour of consumers, it worsened supply chain issues and created phony shortages. The availability of essential goods could have been better communicated by governments and retailers to alleviate consumer fears and reduce demand volatility (Ali et al., 2022).

Reliance on Imports and Global Trade Disruptions

International trade is vital to Malaysia's economy, especially for the retail food supply chain, which relies heavily on imports, making up about 15% of total imports (Department of Statistics Malaysia, 2020). The pandemic disrupted global trade, slowing food shipments and raising costs. Port closures and shipping restrictions led to shortages of key imports, like wheat and dairy, essential for Malaysia's food supply (Ministry of Agriculture and Agro-Based Industry, 2020).

One strategy for Malaysia is to continue using imports to access a variety of food products and optimize prices. This approach can increase resilience by reducing dependence on any single country (Ivanov, 2020).

However, over-reliance on imports makes the retail food supply chain vulnerable to external shocks, such as global trade disruptions. Strengthening food security and minimizing vulnerability can be achieved by boosting domestic production and reducing import dependency (Chowdhury et al., 2021).

The COVID-19 pandemic revealed significant weaknesses in Malaysia’s food supply chain, caused by transport restrictions, labor shortages, fluctuating consumer demand, and heavy import reliance. Some disruptions were unavoidable due to the crisis, but others could have been prevented with better planning and investment in supply chain resilience. Moving forward, Malaysia should focus on improving logistics, diversifying supply sources, and investing in automation and workforce development.

Supply Chain Resilience and Mitigation Strategies

Supply chain resilience is defined as a system's ability to prepare for unexpected events, respond to disruptions, and recover while maintaining essential functions (Ponomarov & Holcomb, 2009). Given the vital role the retail food sector plays in food security and its vulnerability to perishable products and demand volatility, the field is one for which resilience is especially important. Digitalization, diversification, and collaboration are some of the few proposed strategies to enhance supply chain resilience. Predictive analytics, blockchain, and IoT are examples of digital technologies that enhance supply chain visibility and drive real-time decision-making (Dubey et al., 2021). Technological innovations such as blockchain can increase traceability and transparency, and predictive analytics can improve inventory management and minimize waste (Ali et al., 2022). However, the implementation of this technologies in Malaysia is still low due to the constraint of infrastructure and resource.

Another strategy to reduce dependency on single sources and mitigate risks is to diversify suppliers and distribution channels. Public-private partnerships and other collaborative approaches have worked for long-term resilience and systemic vulnerabilities (Ivanov, 2020).

Logistics Optimization in the Retail Food Supply Chain

The pandemic revealed inefficiencies in existing logistics models, particularly in terms of inventory management and transportation. The Malaysian retail food supply chain is characterized by fragmented logistics networks and minimal digitalization, creating barriers to the sector's ability to respond to disruptions (Ministry of Agriculture and Agro-Based Industry, 2020). By leveraging digitalization and automation methods to optimize logistics models, supply chain resilience has been highlighted as an effective approach towards enabling business continuity through minimizing this risk factor.

Similarly, IoT-enabled sensors and real-time tracking systems are helpful to enhance the efficiency of cold chain logistics and minimize spoilage and wastage altogether (Dubey et al., 2021). Furthermore, the incorporation of machine learning algorithms into the logistics models allows the route planning and demand forecasting being optimized, which leads to a better allocation of resources (Chowdhury et al., 2021).

Predictive Analytics and Machine Learning in Supply Chain Management

Through the use of graphs, dashboards and visual tools, visual analytics enables organizations to share actionable insights with stakeholders instantly allowing for better decisions. Such advancements open up opportunities for using visual analytics to monitor key performance indicators (KPIs), such as inventory levels, delivery times, demand forecasts on the retail food supply chain that enables better decision making (Dubey et al., 2021).

Dashboards, for instance, can combine data from multiple sources to offer a detailed view of supply chain performance, uncovering areas of concern and opportunities for improvement (Ali et al., 2022). Visual analytics can be used in the Malaysian retail food supply chain in its early stages but can definitely help in resilience and performance improvements.

The reviewed literature similarly emphasized the importance of pandemic-related disruptions, supply chain resilience, logistics optimization, and predictive analytics in the Malaysian retail food supply chain. Although existing studies have described the impacts of COVID-19 on global supply chains, research is lacking that describes the impacts on the Malaysian retail food industry specifically. This study intends to address the existing gaps by exploring the main causes of disruption, assessing its mitigation approaches, and providing a machine learning-based predictive analytics instrument to improve the resilience of the supply chain.

Theoretical Framework

This research's theoretical framework is built on Supply Chain Resilience Theory and Disruption Management Theory, which serves as a basis for the pandemic's impact on the disruption of retail food supply chains. Resource-Based View (RBV) Theory and Systems Theory provide alternative perspectives that enhance understanding of how resources are strategically managed in the supply chain context, and how its components are interconnected. Collectively, these theories serve as the foundation of the research and help in analysing disruptions, resilience strategies, and predictive analytics of the Malaysian retail food supply chain.

Supply Chain Resilience Theory

Supply Chain Resilience Theory emphasizes a supply chain's capacity to predict, respond, and recover from interruptions, to ensure core operations and limit loss (Ponomarov & Holcomb, 2009). It is through both proactive and reactive efforts; redundancy, flexibility and collaboration which ultimately leads to resilience. During the pandemic of COVID, this theory is useful to identify the disruptions in retail food supply chain due to transportation restriction and labour shortage, and how mitigation measures can help build resilience. Supply Chain Resilience Theory relevant application to this research because of the disruptions the pandemic caused in the Malaysian retail food supply chain and the significance of its analysis, in this study, as this study apply supply chain resilience theory to understand the disruptions and evaluate the effectiveness of mitigation strategies such as digitalization and diversification in helping to ensure resilience.

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Disruption Management Theory

Disruption Management Theory is concerned with identifying, evaluating and mitigating risks from supply chain disruptions (Craighead et al., 2007). The report underscores how critical real-time decision-making, risk assessment and contingency planning are to managing disruptions. The theory is exceptionally resonant in relation to the COVID-19 pandemic, which threw global supply chains into disarray. The study discusses Disruption Management Theory to outline the potential drivers of disruption in the Malaysian retail food supply chain (e.g., hard transportation restrictions, changing consumer demand behaviour) and develop predictive analytics tools to aid real-time decision-making.

Resource-Based View (RBV) Theory

According to RBV theory, firms can attain a competitive advantage through the allocation of their unique resources and capabilities (Barney, 1991). For instance, within the realm of supply chain management, RBV highlights the significance of leveraging strategic resources including digital technologies, expertise labour and collaborative ecosystems to bolster resilience and alleviate disruptions. This study relates the RBV Theory to the effectiveness of different digital technologies, specifically predictive analytics and blockchain, in building resilience for the Malaysian retail food supply chain. It also explores the extent to which firms can utilize their resources to adjust to disruptions and remain competitive.

Systems Theory

The Systems Theory considers supply chains as interconnected systems, in which a change in one factor affects other factors in the entire systems (Bertalanffy, 1968). At this level we understand how the supply chain components interrelate and where we should embrace for entire disruption. In this research, Systems Theory is applied here owing to the interconnectedness of the Malaysian retail food supply chain and how the disruptions in this chain linked producers, distributors, retailers, and consumers. It also calls attention to the need for collaboration in building resilience.

Integration of Theories

These theories form an integrated understanding of factors at play aiding one to conceptualize the role of pandemic-induced disruptions in the` retail food supply chain. Supply Chain Resilience Theory and Disruption Management Theory explain the nature of disruptive elements and how to cope with them, however, RBV Theory and the Systems Theory provide aspects of resource management and system interdependencies from strategic and holistic perspectives.

This study employs Supply Chain Resilience Theory to understand the significant drivers of disruption; Disruption Management Theory to explore predictive analytics tools to inform real-time decision-making; RBV Theory to investigate how digital technologies improve resilience; and Systems Theory to examine the relationship of supply chain components and the necessity for engagement and cooperation between them.

This research is founded in the Supply chain resilience theory, disruption management theory, resource-based view (RBV) theory, and systems theory. These theories offer a strong basis for exploring how restrictions imposed by the Covid-19 disease pandemic affect the Malaysian retail food supply chain and for formulating mechanisms to strengthen resilience. This brings together in this study the 3 theories to provide a more integrative holistic understanding about the challenges imposed by the COVID-19 pandemic and what can be done to ensure long term sustainability of the retail food supply chain.

Hence, the integration of this theory called for a newly theoretical framework which will be called **Integrated Supply Chain Resilience and Adaptation (ISCRA) Framework**. ISCRA stands for **Integrated Supply Chain Resilience & Adaptation**, reflecting its theoretical foundation in resilience, adaptability, resource management, and systemic interconnectivity.

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RESEARCH METHODOLOGY

The objectives of this research study are to measure the effect of pandemic-induced disruptions on the retail food supply chain in Malaysia and formulate strategies for improving the effectiveness of supply chain resilience. It is led by objectives that include identifying the drivers of disruption, evaluating logistics models, developing predictive analytics tools, and creating visualizations of results for all stakeholders involved in decision-making. Research Design The methodology is divided into four phases: research design, data collection, data analysis, and ethical considerations. The combination of the phases ensures the reliability, validity, and applicability of the findings.

Research Design

To reach its goals, this study employs a descriptive and explanatory research design. The research followed a descriptive approach of identifying and describing what the prominent drivers of disruption are in the Malaysian retail food supply chain and an explanatory approach through evaluating the effectiveness of the mitigation strategies and generate predictive analytics tools. The research design is justified through a case study approach that enables an elaborate investigation of the Malaysian retail food supply chain amid the COVID-19 pandemic.

Data Collection

Data of the present study are gathered from secondary sources including annual reports, government publications, industry reports and journals. Secondary data is utilized in this research, as it offers valuable insights into the Malaysian retail food supply chain, along with information on pandemic disruptions and mitigation strategies.

Data Sources:

- Annual reports of Malaysian retail food companies.
- Department of Statistics Malaysia, Ministry of Agriculture and Agro-Based Industry, other relevant publications.
- Industry reports by Nielsen, Malaysian Retail Chain Association and others.
- Academic Journals and Conference Papers on Supply Chain Resilience and Disruption Management.

Sampling:

- The research focuses on major participants in the retail food sector in Malaysia—producers, distributors, and retailers.
- A purposeful sampling technique of companies and data sources is adopted that offers pertinent and extensive insight into the research topic.

Data Analysis

The data analysis occurs in three phases, in line with the research objectives:

a. Descriptive Analysis:

Summarise the key drivers of disruption — such as transportation restrictions, labour shortages and fluctuating consumer demand — and the use of descriptive statistics. Data is analysed with the help of statistical software including SPSS or Excel for trends and patterns in the Malaysian retail food supply chain.

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b. Predictive Analytics:

Secondary data from annual reports is used to build a machine learning model that predicts supply chain disruption. Two algorithms are used to test the model: linear regression and CART decision tree. This study, apply linear regression and a CART decision tree to analyse the relationship between pandemic-related variables and supply chain disruptions, classify disruptions, and identify key drivers. The model is assessed in terms of accuracy, precision, and recall.

c. Visual Analytics:

Graphs, charts and dashboards are used to visualize the predictive analytics output for facilitating decision-making. They utilize tools like Tableau or Power BI to build interactive visualizations that showcase important findings and trends.

Ethical Considerations

Ethical research practices followed in the study include:

- Data Privacy: All data used in this study should not contain sensitive or confidential information, and proper steps should be taken to anonymize the data.
- Citation and Attribution: Properly citing and attributing all sources combined with secondary data in order to prevent plagiarism and give credit to the original authors.
- Transparency: Keeping a clear record of how the research was conducted, from data collection to analysis and interpretation, in order to show and reproduce the research findings.

CONCLUSION

The COVID-19 pandemic has underscored significant vulnerabilities in Malaysia's retail food supply chain, revealing critical weaknesses in logistics, labor availability, and digital adoption. This study seeks to bridge the existing research gap by identifying key disruption factors, assessing the effectiveness of current logistics models, and exploring predictive analytics as a tool to enhance supply chain resilience. The findings from this research will provide valuable insights for both academia and industry by offering a data-driven approach to understanding and mitigating supply chain disruptions. Leveraging theoretical frameworks such as Supply Chain Resilience Theory and Disruption Management Theory, this study aims to contribute to the development of a robust and sustainable supply chain management framework. The integration of predictive analytics models, particularly using machine learning techniques such as linear regression and CART decision trees, will support proactive decision-making and enhance the agility of supply chains in responding to future crises (Dubey et al., 2021; Ali et al., 2022).

By evaluating the limitations of Malaysia's current logistics model and proposing optimized strategies, this study will not only advance academic knowledge but also offer practical recommendations for policymakers, industry stakeholders, and supply chain practitioners. These recommendations will emphasize digital transformation, diversified sourcing strategies, and improved inventory management to strengthen supply chain resilience against future disruptions (Ivanov, 2020; Chowdhury et al., 2021).

Despite its contributions, this research acknowledges limitations, including reliance on secondary data, geographic specificity to Malaysia, and the evolving nature of post-pandemic supply chain disruptions. Future studies should expand the scope to other sectors, incorporate real-time data collection, and explore additional predictive modeling techniques to refine supply chain resilience strategies.

Ultimately, this research aims to serve as a foundation for future discussions on strengthening food security, optimizing logistics efficiency, and ensuring long-term sustainability in Malaysia's retail food supply chain. As

disruptions continue to challenge global supply chains, proactive strategies grounded in empirical research and technological innovation will be crucial for resilience and economic stability.

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