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Research Article

Pandemic Disruptions and Supply Chain Resilience: A Retail Food Perspective

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ABSTRACT

The COVID-19 pandemic has significantly disrupted global supply chains, particularly in the retail food sector, highlighting the need for resilient and adaptive supply chain management strategies. This study investigates the impact of pandemic-related disruptions on the Malaysian retail food supply chain, focusing on identifying key drivers of disruption and developing optimized mitigation strategies to enhance resilience. Using secondary data from annual reports of 15 Malaysian retail food companies, the research employs financial metrics such as Current Ratio, Quick Ratio, Net Profit Margin, and Return on Assets (ROA) to analyze pre-pandemic (2017–2019) and during-pandemic (2020–2022) performance.

The study utilizes both correlation and regression models, including Linear Regression and Random Forest, to predict financial performance and assess the effectiveness of various supply chain strategies. Key findings reveal that liquidity management, operational efficiency, and cost control were critical factors influencing ROA during the pandemic. The analysis also highlights the importance of inventory management and fixed asset utilization in maintaining supply chain resilience.

Furthermore, the research develops a machine learning model for predictive analytics, integrating the results into an interactive Power BI dashboard to facilitate data-driven decision-making. The dashboard provides visualizations of financial trends, model performance, and attribute contributions, enabling stakeholders to identify vulnerabilities and implement targeted strategies.

The study concludes that businesses must adopt proactive measures, such as diversifying suppliers, optimizing inventory, and leveraging digital technologies, to mitigate the impact of future disruptions. By enhancing supply chain resilience, Malaysian retail food companies can better navigate economic uncertainties and ensure the continuity of operations in the face of global challenges.

Keywords: Supply chain resilience, pandemic disruptions, retail food supply chain, Machine learning predictive analytics, sustainable supply chain management

INTRODUCTION

In the current globalized economy, businesses face significant challenges due to supply chain disruptions, which can arise from various factors such as natural disasters, pandemics, transportation issues, labor shortages, and geopolitical conflicts. These disruptions can severely impact the flow of goods and services from suppliers to customers, leading to delays, shortages, increased costs, and, in critical sectors like healthcare, life-threatening consequences for individuals reliant on essential goods such as food and medicine (Fernando et al., 2022). The COVID-19 pandemic has further underscored the vulnerability of global supply chains, particularly in the retail food sector, where disruptions have led to significant economic, social, and environmental repercussions.

The effects of supply chain disruptions extend beyond individual businesses, impacting the broader economy, society, and environment. Economically, disruptions can result in decreased productivity, revenue loss, and increased unemployment. Socially, they can disrupt access to essential goods and services, affecting the quality of life and creating social unrest, particularly among vulnerable populations. Environmentally, disruptions caused by natural disasters or transportation accidents can lead to long-lasting ecological damage, such as oil spills or the release of hazardous materials (Bentahar & Benzidia, 2018).

To address these challenges, businesses must implement effective supply chain disruption management strategies. These strategies involve proactive measures to identify potential risks, develop contingency plans, and promote sustainable practices. A comprehensive contingency plan is essential, including risk assessments, diversification of suppliers, and robust communication channels to keep stakeholders informed during disruptions. Sustainable practices, such as responsible sourcing and environmentally conscious operations, can also enhance supply chain resilience and reduce the risk of future disruptions (Khan et al., 2018).

The COVID-19 pandemic has highlighted the need for more resilient and adaptable supply chains, particularly in the retail food sector, where disruptions have led to food shortages, price fluctuations, and compromised product integrity. This study focuses on the Malaysian retail food supply chain, aiming to investigate the pandemic-related variables and challenges that act as major drivers of disruption. By analyzing financial data from annual reports of 15 Malaysian retail food companies, the research seeks to determine the parameters of the current logistics model and design optimized supply chain mitigation strategies to increase resilience.

The food supply chain is a complex network that involves the integration and coordination of various activities, from production and processing to distribution and consumption. The globalization of the food industry has introduced additional complexities and risks, such as longer transportation times, potential supply disruptions, and increased exposure to contamination or quality issues (Zhong et al., 2017). The COVID-19 pandemic has exacerbated these challenges, leading to significant disruptions in food production, transportation, and distribution processes, resulting in shortages, price fluctuations, and compromised product integrity (Jafri et al., 2021).

The pandemic has also highlighted the importance of supply chain resilience (SCRes), which refers to a firm's ability to anticipate, prepare for, rapidly respond to, and recover from disturbances, thereby meeting unpredictable demand and gaining competitive advantages (Ambulkar et al., 2015). In the context of the food supply chain, resilience is crucial to ensure the continuity of operations and the availability of safe and nutritious food for consumers, especially during times of crisis (Béné, 2020).

1.1 Problem Statement

The COVID-19 pandemic has caused unprecedented disruptions in the global food supply chain, particularly in the retail food sector. In Malaysia, the pandemic has led to significant challenges, including labor shortages, transportation restrictions, and increased costs of goods sold (COGS), which have impacted the financial performance of retail food companies (Ling et al., 2021). These disruptions have highlighted the vulnerabilities in the Malaysian retail food supply chain, emphasizing the need for more resilient and adaptive strategies to mitigate the impact of future disruptions.

Despite the growing body of research on supply chain disruptions, there is limited comprehensive research on the sustainability of supply chain disruption and the specific challenges faced by the Malaysian retail food sector during the pandemic. This study aims to address this gap by investigating the pandemic-related variables and challenges

that act as major drivers of disruption in the Malaysian retail food supply chain and developing optimized mitigation strategies to enhance resilience.

1.2 Research Questions:

1.2.1 What are the pandemic-related variables and challenges that act as major drivers of disruption in the Malaysian retail food supply chain?

1.2.2 What are the parameters of the current logistics model in the Malaysian retail food supply chain, and how can they be optimized to increase resilience?

1.2.3 How can machine learning models be developed for predictive analytics in the Malaysian retail food industry using secondary data from annual reports?

1.2.4 How can the predictive models be represented in suitable graphs to assist the decision-making process?

1.3 Research Objectives

1.3.1 To investigate the pandemic-related variables and challenges that act as major drivers of disruption in the Malaysian retail food supply chain.

1.3.2 To determine the parameters of the present state logistics model and design optimized supply chain mitigation strategies that increase the resilience of the Malaysian retail food supply chain.

1.3.3 To develop a Machine Learning model for predictive analytics in Malaysian retail food industries using secondary data from annual reports. The model will be tested using linear regression and CART decision tree.

1.3.4 To represent the prediction of the developed model in suitable graphs to assist the decision-making process.

LITERATURE REVIEW

2.1 Supply Chain Disruptions

Supply chain disruptions can result from various factors, including natural disasters, pandemics, political unrest, and cyber-attacks. These disruptions can lead to adverse effects such as increased costs, decreased efficiency, and diminished customer satisfaction. The COVID-19 pandemic has further emphasized the need for research on the resilience of supply chains during pandemics and the role of digital technologies in mitigating disruptions (Ivanov et al., 2017). Businesses require more resilient and adaptable supply chains capable of effectively managing disruptions, as these can trigger broader economic disturbances and shortages of crucial commodities, leading to inflationary pressures and potential implications for national security (Khalili et al., 2017).

Recognizing the importance of addressing both disruptions and recovery is crucial in supply chain design and planning. Businesses should take a proactive approach by identifying potential disruptions and developing strategies to mitigate their impact. Simultaneously, they should also establish recovery plans to minimize the consequences when disruptions occur. This comprehensive approach ensures a more resilient and efficient supply chain (Yu et al., 2017).

2.2 Strategies Facing Supply Chain Disruptions

Implementing sustainable practices in supply chain operations is a valuable strategy. This can involve reducing waste, optimizing energy usage, and adopting environmentally friendly practices. Sustainable operations not only minimize the environmental impact but also contribute to the long-term viability and resilience of the supply chain (Pujawan et al., 2021). Proactive planning, risk assessment, diversification, and sustainable practices help mitigate the impact of disruptions and ensure continuity in the face of challenges. Continued research in this area can further enhance our understanding of supply chain disruption and provide valuable insights for businesses seeking to improve their supply chain management practices (Handfield et al., 2020).

The role of digital technologies in mitigating the impact of disruptions is also critical. Digital technologies offer opportunities for improved supply chain visibility, agility, and collaboration. They enable businesses to respond swiftly to disruptions, track inventory in real-time, and optimize logistics and distribution processes. However, further research is needed to explore the full potential of digital technologies in facilitating supply chain recovery and enhancing resilience (Ivanov & Dolgui, 2019).

2.3 Food Supply Chain

The management of the food supply chain involves the integration and coordination of various activities spanning from production and processing to distribution and consumption of food products. This comprehensive coordination is essential to uphold the safety and quality standards of diverse food items. However, the existing structure of the food supply chain encounters numerous challenges as a result of growing globalization and the rising need for healthier and more nutritious food options (Zhong et al., 2017).

The food supply chain is impacted by various external factors such as climate change, natural disasters, and disease outbreaks. These events can disrupt production, transportation, and distribution processes, leading to shortages, price fluctuations, and compromised product integrity. To mitigate these risks, supply chain management must be agile and adaptable, incorporating contingency plans and risk management strategies to ensure uninterrupted flow and availability of food products (Karlsen et al., 2013).

2.3.1 Efficient Food Supply Chain

Efficient and effective supply chain management is crucial for several reasons. First and foremost, it directly impacts the quality and safety of food products. Proper handling, storage, and transportation practices are essential to prevent contamination, spoilage, and deterioration of the products throughout the supply chain. Secondly, supply chain management influences the availability and accessibility of food products. Timely and accurate forecasting of demand, efficient production scheduling, and optimal inventory management ensure that food products are readily available to meet consumer needs (Beske et al., 2014).

Additionally, effective supply chain management enables traceability and transparency in the food supply chain. This is crucial for meeting regulatory requirements, addressing food safety incidents, and building consumer trust. Traceability systems can track the origin, processing, and distribution of food products, facilitating recalls and investigations if necessary (Berry et al., 2015). Lastly, supply chain management in the food industry also intersects with broader sustainability goals. By adopting sustainable practices, such as minimizing waste, reducing energy consumption, and promoting environmentally friendly packaging and transportation, companies can contribute to mitigating the environmental impact of the food supply chain.

2.3.2 Sustainable Food Supply Chain

The concept of sustainability has gathered significant research interest within the area of food supply chain management. A thorough examination of existing literature on food sustainable supply chain management (FSSCM) has shed light on crucial factors, practices, and potential avenues for future exploration in sustainable supply chain management within the food industry. This recognition highlights the significance of integrating sustainability considerations into the food supply chain, with the aim of ensuring the industry's long-term viability (Haleem & Sufiyan, 2021).

Specific sustainable supply chain management practices that can be adopted in the food industry include sourcing ingredients from sustainable and ethical suppliers, implementing energy-efficient production processes, utilizing renewable energy sources, optimizing transportation routes to reduce emissions, implementing waste reduction and recycling initiatives, and promoting responsible consumption patterns among consumers. Future directions for sustainable supply chain management in the food industry include exploring emerging technologies, such as blockchain, Internet of Things (IoT), and artificial intelligence (AI), to enhance traceability, transparency, and efficiency within the supply chain (Pallazo & Vollero, 2022).

2.4 Impact of Pandemic on Food Availability

The COVID-19 pandemic has had a profound impact on food availability and accessibility worldwide. Measures such as home confinement, travel bans, and business closures have disrupted every stage of the food supply chain, with major impacts on food distribution. Different agricultural sectors, such as crop, livestock, and fishery, have been hit hard by the pandemic. In China, COVID-19 has caused a higher impact on livestock farming due to limited access to animal feed and a shortage of labor. Travel bans in many countries have affected the delivery of breeding stock for poultry, and fish farmers have been unable to sell their harvest due to difficulties in aquaculture production caused by a lack of seed and feed (Jafri et al., 2021).

The pandemic has also led to significant challenges in food demand and food security. Panicked consumers have resorted to stockpiling food, which has affected food availability and prices. The price of commodities, however, depends on the country and their policy to control the pandemic (Poudel et al., 2020). Food insecurity, malnutrition, and obesity represent three of the most complex conditions threatening the livelihoods of populations globally. The outbreak of the COVID-19 pandemic has been a proximate cause of a transcontinental food emergency, with impending threats to the food environment and nutrition, particularly in the most vulnerable populations (Alam et al., 2016; Huizar et al., 2021).

2.5 Retail Food Supply Chain during Pandemic Disruptions

Supply chain operations during pandemic times are characterized by a long-term disrupted state in the supply network, an unstable current situation, and uncertainty about future developments in the markets, supply base, and capacities. These characteristics entail a danger of supply chain collapses and interruption of the provision of goods and services. The existing research on the pandemic's impacts on supply chains focuses on two areas: how to predict the pandemic's impacts on supply chains and how to examine supply chain reactions to the pandemic (Chin, 2020; Singh et al., 2021).

The Viable Supply Chain model triangulates supply chain management under pandemic conditions and spans the perspectives of supply chain ecosystems, multistructural network designs, and viability capabilities. This model emphasizes the need to create a sustainable state in which the supply chain is able to maintain itself and survive in a changing environment through a redesign of structures and replanning of performance with long-term impacts (Abideen et al., 2021b; Singh et al., 2021).

2.5.1 Transport Impact during the pandemic

The COVID-19 pandemic has disrupted transportation, particularly in the food sector, with limited travel and lockdown measures. Sea freight has become more accessible due to reduced demand, while rail transport has become less labor-intensive. However, container shortages due to quarantine measures need to be addressed to ensure the smooth flow of goods within the supply chain. Close coordination between stakeholders in the food industry, transportation providers, and regulatory authorities is crucial to adapt to these challenges.

Road transport, particularly truck, has demonstrated its ability to adapt to disruptions due to reduced competition. However, truck drivers in Canada faced challenges accessing toilets due to closures or limited operating hours of roadside restaurants. To sustain and improve truck transport performance, it is crucial to address specific challenges faced by truck drivers and optimize online food delivery systems.

2.6 Disruption-Based Scenario Planning

To counteract the long-term disrupted state caused by the pandemic, businesses must go beyond an instantaneous event-driven understanding and properly strategize logistics routes. The pandemic creates a long-term disrupted state characterized by an unstable current situation and uncertainty about future developments in the markets, supply base, and capacities. This entails a danger of supply chain collapses and interruption of the market provision of goods and services (Dmitry Ivanov, 2021).

Scenario planning is a strategic tool that organizations can use to effectively manage supply chain disruptions. By creating and analyzing multiple scenarios, organizations can proactively prepare for a wide range of potential futures, enabling them to adapt swiftly to changing circumstances. This approach fosters resilience, enhances decision-making capabilities, and promotes proactive strategies to navigate uncertainty and volatility in the supply chain landscape (Varum & Melo, 2010).

2.7 Advantages of Transportation and Network Optimization during Disruptions

Transportation and network optimization are critical during disruptions, as they help businesses minimize costs and ensure timely delivery of goods. Route optimization tools can help businesses plan last-mile routing strategies by mapping out itineraries in a way that minimizes transportation costs and satisfies customer demands on time. Advanced route optimization software can consider estimated lead times when planning routes, ensuring on-time delivery and preventing financial and reputational risks (Alfayad, 2020; D Ivanov, 2020).

2.8 Data for Supply Chain Analytics

Data analytics plays a crucial role in enhancing supply chain management by leveraging data from various sources to drive informed decision-making. With the availability of data from applications, infrastructure, third-party sources, and emerging technologies like the Internet of Things (IoT), organizations can gain valuable insights and improve their strategic, tactical, and operational processes within the supply chain (Sharma et al., 2020).

METHODOLOGY

This study employs a quantitative research approach to investigate the impact of the COVID-19 pandemic on the Malaysian retail food supply chain. The research methodology was adapted to focus on secondary data analysis due to the confidentiality of primary data from respondents, which included large, medium, and small companies. Instead, the study utilized annual reports from companies listed on Bursa Malaysia Kuala Lumpur, specifically those related to supply chain, logistics, and food industries. The selected companies were chosen based on their relevance to Malaysia's retail food sector, ensuring comprehensive data coverage for the study period.

2.9 Data Collection

The study analyzed data from 15 companies operating within Malaysia's retail food sector. The companies selected for analysis include:

1. Malayan Flour Mills
2. MSM Malaysia Holdings
3. OCB Berhad
4. PPB Group Berhad
5. Saudee Group
6. Nestle Malaysia
7. Oriental Food Industries
8. Apollo Food Holdings Bhd
9. CCK Consolidated Holdings Bhd
10. CI Holdings Berhad
11. Dutch Lady Milk Industries Berhad
12. Fraser & Neave Holdings Bhd
13. Guan Chong Bhd
14. Hwa Tai Industries Berhad
15. Kawan Food Bhd

The annual reports of these companies were collected from their official websites, covering two timelines: pre-pandemic (2017–2019) and during-pandemic (2020–2022). The financial data extracted from these reports included key performance indicators such as:

1. Current Ratio
2. Quick Ratio
3. Net Profit Margin
4. Operating Profit
5. Debt Ratio
6. Inventory Turnover
7. Return on Assets (ROA)

Additional attributes such as company names and specific years were included to provide context for the data.

2.10 Data Preparation

The extracted metrics were systematically paired to form model-specific datasets. For correlation models, attributes such as Current Ratio, Quick Ratio, and Net Profit Margin were paired with ROA. For regression models, monetary values such as Current Assets, Current Liabilities, and Costs of Goods Sold (COGS) were included. The data was

segmented into two temporal categories: pre-pandemic years (2017–2019) and pandemic years (2020–2022). This division facilitated a comparative analysis to assess predictive accuracy and financial performance under differing economic conditions.

2.11 Model Development

The study developed machine learning models using WEKA software to analyze the data. Two types of models were developed:

3.3.1 Correlation Models: These models focused on exploring the relationships between individual financial metrics and ROA. The correlation coefficient was used to interpret the strength and direction of these relationships.

3.3.2 Regression Models: These models aimed to predict ROA using multiple attributes. Both Linear Regression and Random Forest algorithms were employed to evaluate their predictive capabilities. Linear Regression provided a foundational statistical approach, while Random Forest offered a more flexible framework for handling non-linear relationships and interactions within the data.

The outputs from these models included Predicted ROA, and the evaluation metrics used were Correlation Coefficient and Root Mean Squared Error (RMSE). The RMSE measures the average magnitude of the prediction errors, with values closer to zero indicating better model performance.

2.12 Dashboard Integration

The results from the models were integrated into an interactive Power BI dashboard to facilitate data visualization and decision-making. The dashboard consisted of four interactive pages:

3.4.1 Page 1: Company Information
This page presented company locations using a map visual, highlighting ROA trends over time. Users could filter data by company name and year to explore specific datasets.

3.4.2 Page 2: Correlation Models
This page displayed scatter plots and bar charts for correlation models, showing Actual ROA vs. Predicted ROA. Users could select specific models to view the outcomes, with bar charts illustrating the performance of each model based on Correlation Coefficient and RMSE.

3.4.3 Page 3: Regression Models
This page provided scatter plots and bar charts for regression models, illustrating Actual ROA vs. Predicted ROA. Users could select specific models to view the outcomes, with bar charts showing the performance of each model based on Correlation Coefficient and RMSE.

3.4.4 Page 4: Comparative Analysis
This page focused on comparative analysis, displaying attribute importance and performance differences between Linear Regression and Random Forest models. It also included scatter plots showing the difference in outcomes between the two models.

2.13 Data Analysis

The study employed regression analysis to investigate the relationship between financial variables and ROA during the pre-pandemic and pandemic periods. Key financial variables analyzed included:

1. Current Assets
2. Current Liabilities
3. Cost of Goods Sold (COGS)
4. Inventory Cost
5. Total Equity
6. Operating Profit
7. Net Profit

The R-squared values and coefficient values were used to interpret the strength and direction of these relationships. For example, during the pandemic, the relationship between Current Assets and ROA increased slightly, indicating that companies focused more on managing liquidity to cope with supply chain disruptions.

2.14 Model Evaluation

The performance of the models was evaluated based on Correlation Coefficient and RMSE. For example, in the pre-pandemic period, the Correlation Coefficient for the relationship between Net Profit Margin and ROA was 0.5601, indicating a strong positive relationship. During the pandemic, this value increased slightly, suggesting that profitability remained critical in navigating disruptions.

The RMSE values for the models ranged between 0.08 and 0.10, indicating relatively low prediction errors. This range suggests that the models were reasonably accurate in predicting ROA, even during the turbulent pandemic period.

3.7 Attribute Ranking

The Random Forest model was used to rank the importance of financial attributes in predicting ROA. For the pre-pandemic period (2017–2019), the most important attributes were:

1. Net Profit Margin
2. Debt to Equity Ratio
3. Debt Ratio
4. Fixed Asset Turnover
5. Inventory Turnover
6. Current Ratio
7. Quick Ratio
8. Operating Profit

For the pandemic period (2020–2022), the ranking shifted slightly, with Fixed Asset Turnover becoming more important, reflecting the need for operational efficiency during the crisis.

The methodology employed in this study provides a robust framework for analyzing the impact of the COVID-19 pandemic on the Malaysian retail food supply chain. By leveraging secondary data from annual reports, developing machine learning models, and integrating the results into an interactive dashboard, the study offers valuable insights into the financial performance and resilience of the retail food sector during the pandemic. The findings from this research can assist stakeholders in making data-driven decisions to enhance supply chain resilience and mitigate future disruptions.

FINDINGS AND DISCUSSION

2.15 Results from Data Analysis to Support Objective 1

Objective 1: To investigate the pandemic-related variables and challenges that act as major drivers of disruption in the Malaysian retail food supply chain.

The study analyzed financial variables such as Current Assets, Current Liabilities, Cost of Goods Sold (COGS), Inventory Cost, Total Equity, Operating Profit, and Net Profit to identify the key drivers of disruption during the pandemic. The analysis revealed the following insights:

4.1.1 Current Assets: During the pre-pandemic period, the relationship between Current Assets and ROA was weak ($R^2 = 0.0289$). However, during the pandemic, this relationship strengthened slightly ($R^2 = 0.0530$), indicating that companies focused more on managing liquidity to cope with supply chain disruptions and changes in consumer demand. The coefficient value also increased from 0.0624 to 0.0914, suggesting that Current Assets such as cash reserves and inventory became more critical for maintaining ROA during the crisis.

4.1.2 Current Liabilities: The relationship between Current Liabilities and ROA was moderate in the pre-pandemic period (R^2 = 0.1290) but slightly decreased during the pandemic (R^2 = 0.1144). This suggests that relying on short-term debt became less effective for maintaining profitability due to external shocks and reduced consumer demand.

4.1.3 Cost of Goods Sold (COGS): The relationship between COGS and ROA was weak in the pre-pandemic period (R^2 = 0.0275) but increased slightly during the pandemic (R^2 = 0.0404). The coefficient value also rose from 0.0762 to 0.1036, indicating that COGS became a more significant factor in influencing ROA during the pandemic. This reflects the impact of rising procurement costs and logistical challenges on overall profitability.

4.1.4 Inventory Cost: The relationship between Inventory Cost and ROA was weak in both periods, but the coefficient value decreased during the pandemic, suggesting that inventory management became more challenging due to supply chain disruptions.

4.1.5 Total Equity: The relationship between Total Equity and ROA was extremely weak in both periods, indicating that companies did not heavily rely on equity to navigate financial challenges during the pandemic.

4.1.6 Operating Profit: The relationship between Operating Profit and ROA was strong in both periods, with a slight decrease during the pandemic (R^2 = 0.2384 compared to 0.2932 in the pre-pandemic period). This highlights the continued importance of operational efficiency in maintaining profitability, even during disruptions.

Key Drivers of Disruption: The analysis identified the following key drivers of disruption during the pandemic:

a. Increased focus on liquidity management (Current Assets).
b. Rising costs (COGS and Inventory Costs).
c. Continued reliance on short-term financing (Current Liabilities) rather than equity.
d. Operational profitability (Operating Profit) as a critical factor for maintaining financial performance.

2.16 Results from Data Analysis to Support Objective 2

Objective 2: To determine the parameters of the present state logistics model and design optimized supply chain mitigation strategies that increase the resilience of the Malaysian retail food supply chain.

The study used correlation analysis to evaluate the relationship between financial ratios and ROA. The key findings include:

4.2.1 Net Profit Margin: The correlation between Net Profit Margin and ROA was strong in both periods, with a slight increase during the pandemic (Correlation Coefficient = 0.5601 pre-pandemic, 0.5903 during-pandemic). This indicates that profitability remained a critical factor in navigating disruptions.

4.2.2 Operating Profit: The correlation between Operating Profit and ROA was also strong, though slightly lower during the pandemic (Correlation Coefficient = 0.4836 pre-pandemic, 0.4501 during-pandemic). This highlights the importance of operational efficiency in maintaining financial performance.

4.2.3 Debt Ratio: The correlation between Debt Ratio and ROA was positive in the pre-pandemic period (Correlation Coefficient = 0.2845) but turned negative during the pandemic (Correlation Coefficient = -0.4624). This suggests that high leverage exacerbated financial challenges during the crisis.

4.2.4. Fixed Asset Turnover: The correlation between Fixed Asset Turnover and ROA decreased during the pandemic (Correlation Coefficient = 0.2528 compared to 0.3319 pre-pandemic), indicating inefficiencies in asset utilization due to supply chain disruptions.

Optimized Mitigation Strategies: Based on the analysis, the following strategies are recommended to enhance supply chain resilience:

a. Improve Inventory Management: Enhance inventory turnover to reduce costs and improve efficiency.
b. Strengthen Fixed Asset Utilization: Optimize the use of fixed assets to boost operational efficiency.
c. Manage Debt Levels: Reduce reliance on short-term debt to mitigate financial risks during disruptions.

4.3 Results from Data Analysis to Support Objective 3 and 4

Objective 3: To develop a Machine Learning model for predictive analytics in Malaysian retail food industries using secondary data from annual reports. The model will be tested using linear regression and CART decision tree.

Objective 4: To represent the prediction of the developed model in suitable graphs to assist the decision-making process.

The study developed machine learning models using Linear Regression and Random Forest algorithms to predict ROA. The models were evaluated based on Correlation Coefficient and Root Mean Squared Error (RMSE). The key findings include:

4.3.1 Linear Regression: The Linear Regression model performed well in the pre-pandemic period, with a high Correlation Coefficient (0.8352) and low RMSE (0.0546). However, its performance declined slightly during the pandemic (Correlation Coefficient = 0.5903, RMSE = 0.0863), reflecting the increased complexity of financial dynamics during the crisis.

4.3.2 Random Forest: The Random Forest model outperformed Linear Regression during the pandemic, demonstrating its ability to handle non-linear relationships and complex interactions within the data. The model identified Net Profit Margin, Fixed Asset Turnover, and Debt Ratio as the most important attributes for predicting ROA during the pandemic.

4.3.3 Dashboard Integration: The results from the models were integrated into an interactive Power BI dashboard, which included four pages:

a. Page 1: Company locations and ROA trends over time.
b. Page 2: Scatter plots and bar charts for correlation models, showing Actual ROA vs. Predicted ROA.
c. Page 3: Scatter plots and bar charts for regression models, illustrating Actual ROA vs. Predicted ROA.
d. Page 4: Comparative analysis, displaying attribute importance and performance differences between Linear Regression and Random Forest models.

The dashboard provided stakeholders with actionable insights to enhance decision-making and improve supply chain resilience.

4.4 Summary of Findings

4.4.1 Model Performance: The study revealed variability in predictive accuracy between the pre-pandemic and pandemic periods. During the pre-pandemic years (2017–2019), the models exhibited stable Correlation Coefficient and RMSE values, reflecting consistent financial conditions. In contrast, the pandemic years (2020–2022) showed greater variances in these metrics, indicative of economic disruptions and increased uncertainty.

4.4.2 Regression vs. Random Forest Models: Linear Regression excelled in the pre-pandemic period due to the linear relationships between financial metrics. However, Random Forest outperformed during the pandemic, demonstrating its ability to handle non-linear and complex interactions.

4.4.3 Geographical Analysis: The dashboard illustrated ROA trends across company locations, highlighting regional performance variations and the impact of the pandemic on different areas.

4.4.4 Attribute Contribution: The evaluation of attribute importance scores underscored the significance of key financial metrics such as Net Profit Margin, Fixed Asset Turnover, and Debt Ratio in predicting ROA.

4.4.5 Interactive Dashboard Insights: The Power BI dashboard facilitated a comprehensive analysis of financial data, enabling stakeholders to identify trends and evaluate model performance effectively. The integration of filters and dynamic visualizations allowed users to interact with the data and extract meaningful insights tailored to their needs.

The findings of this study provide valuable insights into the impact of the COVID-19 pandemic on the Malaysian retail food supply chain. By analyzing financial data and developing predictive models, the research highlights the importance of liquidity management, cost control, and operational efficiency in maintaining financial performance during disruptions. The integration of machine learning models into an interactive dashboard offers a powerful tool for stakeholders to enhance decision-making and improve supply chain resilience. The study underscores the need for businesses to adopt proactive measures, such as diversifying suppliers, optimizing inventory, and leveraging

digital technologies, to mitigate the impact of future disruptions and ensure the continuity of operations in the face of global challenges.

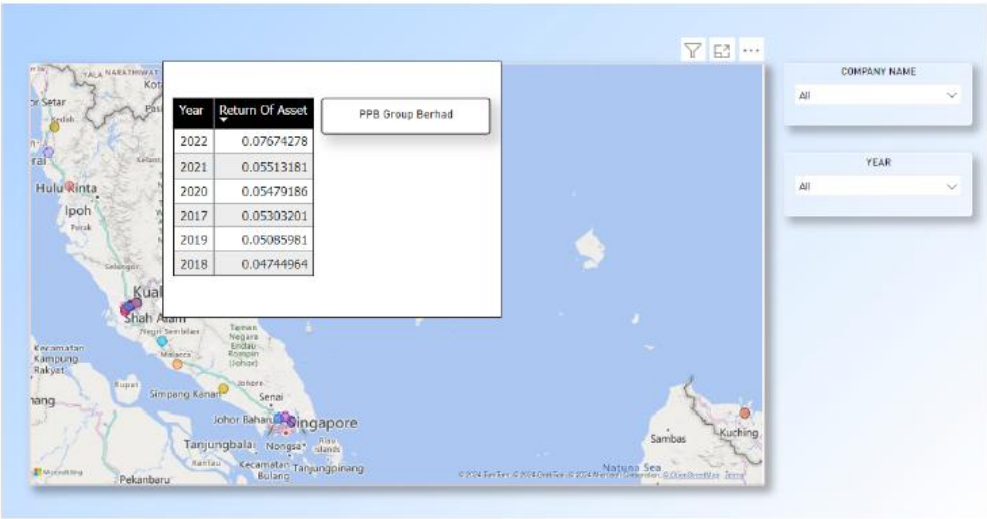
4.5 Dashboard Integration

The results from the machine learning models developed in this study were integrated into an interactive Power BI dashboard to facilitate data visualization and decision-making. The dashboard was designed to provide stakeholders with actionable insights into the financial performance and resilience of the Malaysian retail food supply chain during the COVID-19 pandemic. The dashboard consists of four interactive pages, each focusing on different aspects of the data analysis.

4.5.1. Page 1: Company Information

Purpose: This page provides an overview of the companies included in the study, highlighting their locations and Return on Assets (ROA) trends over time.

- Visualization: A map visual is used to display the locations of the 15 companies analyzed in the study. Users can view the ROA trends for each company from 2018 to 2022.
- Interactivity: Users can filter the data by company name and year to explore specific datasets. The interactive filters allow users to focus on individual companies or specific time periods.
- Insights: This page helps stakeholders identify regional performance variations and understand how different companies were impacted by the pandemic.



Page 1: Presented company locations using a map visual, highlighting ROA trends over time.

4.5.2 Page 2: Correlation Models

Purpose: This page displays the outcomes of correlation models, showing the relationship between individual financial metrics and ROA.

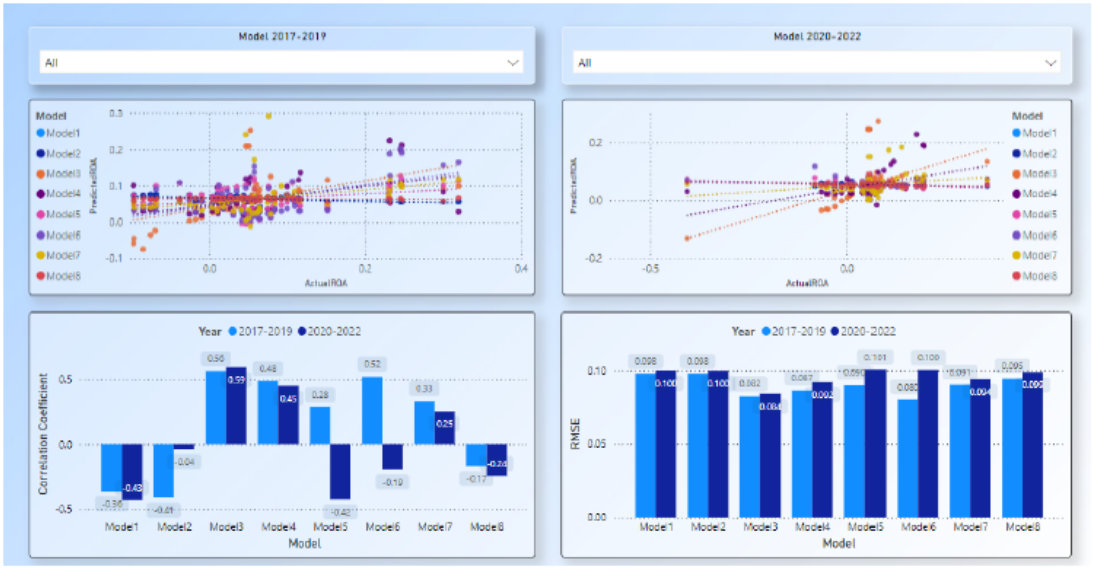
4.5.2.1 Visualization: Scatter plots and bar charts are used to illustrate the results of different correlation models. The scatter plots show Actual ROA vs. Predicted ROA, while the bar charts display the performance of each model based on Correlation Coefficient and Root Mean Squared Error (RMSE).

4.5.2.2 Interactivity: Users can select specific models to view the outcomes. The models included are:

i. Model 1: Current Ratio vs. ROA
ii. Model 2: Quick Ratio vs. ROA
iii. Model 3: Net Profit Margin vs. ROA
iv. Model 4: Operating Profit vs. ROA
v. Model 5: Debt Ratio vs. ROA
vi. Model 6: Debt to Equity Ratio vs. ROA
vii. Model 7: Fixed Asset Turnover vs. ROA

viii. Model 8: Inventory Turnover vs. ROA

4.5.2.3 Insights: The bar charts reveal that Models 3, 4, and 7 consistently show positive correlation coefficients across both timelines (2017–2019 and 2020–2022), indicating stable and strong relationships between the predicted and actual ROA values. In contrast, Models 1, 2, and 8 display negative correlation coefficients, suggesting poor predictive performance. Models 5 and 6 show a shift from positive to negative correlations during the pandemic, highlighting the need for model recalibration in response to changing market conditions.



Page 2: Displayed scatter plots and bar charts for correlation models, showing Actual ROA vs Predicted ROA.

4.5.3 Page 3: Regression Models

Purpose: This page presents the outcomes of regression models, illustrating the relationship between multiple financial attributes and ROA.

4.5.3.1 Visualization: Scatter plots and bar charts are used to display the results of different regression models. The scatter plots show Actual ROA vs. Predicted ROA, while the bar charts illustrate the performance of each model based on Correlation Coefficient and RMSE.

4.5.3.2 Interactivity: Users can select specific models to view the outcomes. The models included are:

i. Model 1: Current Assets vs. ROA
ii. Model 2: Current Liabilities vs. ROA
iii. Model 3: Cost of Goods Sold (COGS) vs. ROA
iv. Model 4: Inventory Cost vs. ROA
v. Model 5: Equity vs. ROA
vi. Model 6: Operating Profit vs. ROA
vii. Model 7: Net Profit vs. ROA
viii. Model 8: Multiple Attributes (Current Assets, Current Liabilities, COGS, Inventory Cost, Equity, Operating Profit, Net Profit) vs. ROA

4.5.3.3 Insights: The bar charts reveal that Models 1, 2, 3, 4, 5, 7, and 8 consistently show positive correlation coefficients across both timelines, indicating strong relationships between the predicted and actual ROA values. Model 6 displays negative correlation coefficients, suggesting poor predictive performance. The RMSE values for the regression models range between 0.08 and 0.10, indicating relatively low prediction errors and reasonable model accuracy.

Page 3: Displayed scatter plots and bar charts for regression models, illustrating Actual ROA vs Predicted ROA.

4.5.4 Page 4: Comparative Analysis

Purpose: This page focuses on comparative analysis, displaying the importance of different financial attributes and the performance differences between Linear Regression and Random Forest models.

4.5.4.1 Visualization: The page includes bar charts showing the attribute importance scores generated by the Random Forest model. It also features scatter plots comparing the outcomes of Linear Regression and Random Forest models.

4.5.4.2 Interactivity: Users can explore the ranking of financial attributes for different time periods (2017–2019 and 2020–2022) and compare the performance of the two models.

4.5.4.3 Insights: The Random Forest model identified the following attributes as the most important for predicting ROA:

2017–2019:

1. Net Profit Margin
2. Debt to Equity Ratio
3. Debt Ratio
4. Fixed Asset Turnover
5. Inventory Turnover
6. Current Ratio
7. Quick Ratio
8. Operating Profit

2020–2022:

1. Net Profit Margin
2. Fixed Asset Turnover
3. Debt Ratio
4. Debt to Equity Ratio
5. Current Ratio

6. Inventory Turnover

7. Quick Ratio

8. Operating Profit

The shift in attribute importance during the pandemic reflects the changing priorities of companies, with a greater focus on operational efficiency (e.g., Fixed Asset Turnover) and profitability (e.g., Net Profit Margin) to navigate disruptions.

The Power BI dashboard provides a comprehensive and interactive platform for stakeholders to analyze the financial performance of the Malaysian retail food supply chain during the COVID-19 pandemic. By integrating machine learning models with dynamic visualizations, the dashboard enables users to:

1. Identify Trends: Visualize ROA trends over time and across different companies.
2. Evaluate Model Performance: Compare the accuracy of Linear Regression and Random Forest models using Correlation Coefficient and RMSE metrics.
3. Understand Attribute Importance: Explore the ranking of financial attributes and their impact on ROA.
4. Make Data-Driven Decisions: Use the insights generated by the dashboard to develop strategies for enhancing supply chain resilience and mitigating future disruptions.

The integration of machine learning models into the dashboard not only enhances predictive accuracy but also equips industry participants with actionable insights to navigate an increasingly complex economic landscape.

SUMMARIZATION OF RESULTS

The study revealed key insights into the performance of correlation and regression models across different time periods, providing a comprehensive understanding of the impact of the COVID-19 pandemic on the Malaysian retail food supply chain. The findings are summarized as follows:

5.1 Model Performance Analysis

5.1.1 Pre-Pandemic Period (2017–2019): The models exhibited stable Correlation Coefficient and Root Mean Squared Error (RMSE) values, reflecting consistent financial conditions. The Linear Regression model performed particularly well, with a high Correlation Coefficient (0.8352) and low RMSE (0.0546), indicating strong predictive accuracy.

5.1.2 Pandemic Period (2020–2022): The models showed greater variability in performance, with increased RMSE values and shifts in Correlation Coefficients. This reflects the economic disruptions and increased uncertainty caused by the pandemic. The Random Forest model outperformed Linear Regression during this period, demonstrating its ability to handle non-linear and complex interactions within the data.

5.2 Regression vs. Random Forest Models

5.2.1 Linear Regression: This model excelled in the pre-pandemic period due to the linear relationships between financial metrics. However, its performance declined slightly during the pandemic, as the financial dynamics became more complex and non-linear.

5.2.2 Random Forest: This model outperformed Linear Regression during the pandemic, showcasing its robustness in handling complex data interactions. It identified Net Profit Margin, Fixed Asset Turnover, and Debt Ratio as the most important attributes for predicting ROA during the crisis.

5.3 Geographical Analysis

5.3.1 Page 1 of the Dashboard: The geographical analysis illustrated ROA trends across company locations, highlighting regional performance variations. This visualization helped stakeholders understand how different companies and regions were impacted by the pandemic, providing actionable insights for targeted interventions.

5.4 Attribute Contribution Evaluation

5.4.1 Attribute Importance: The Random Forest model ranked the importance of financial attributes for predicting ROA. In the pre-pandemic period, the top attributes were:

1. Net Profit Margin
2. Debt to Equity Ratio

3. Debt Ratio
4. Fixed Asset Turnover
5. Inventory Turnover

During the pandemic, the ranking shifted slightly, with Fixed Asset Turnover becoming more important, reflecting the need for operational efficiency during the crisis.

5.5 Key Insights

The shift in attribute importance during the pandemic highlights the changing priorities of companies, with a greater focus on operational efficiency and profitability to navigate disruptions.

5.6 Interactive Dashboard Insights

- Dashboard Functionality: The Power BI dashboard provided a comprehensive and interactive platform for stakeholders to analyze financial data. The integration of machine learning models with dynamic visualizations enabled users to:
- Identify Trends: Visualize ROA trends over time and across different companies.
- Evaluate Model Performance: Compare the accuracy of Linear Regression and Random Forest models using Correlation Coefficient and RMSE metrics.
- Understand Attribute Importance: Explore the ranking of financial attributes and their impact on ROA.
- Make Data-Driven Decisions: Use the insights generated by the dashboard to develop strategies for enhancing supply chain resilience and mitigating future disruptions.

KEY FINDINGS

6.1 Increased Focus on Liquidity: Companies shifted their focus towards managing Current Assets (cash, receivables, and inventory) more effectively to cope with supply chain disruptions and changes in consumer demand.

6.2 Rising Costs: Cost of Goods Sold (COGS) and Inventory Costs became more influential in determining ROA during the pandemic, reflecting the impact of rising procurement costs and logistical challenges.

6.3 Operational Profitability: Despite disruptions, Operating Profit remained a significant driver of ROA, suggesting that companies continued to focus on maintaining profitability through efficient operations.

6.4 Debt Management: The negative correlation between Debt Ratio and ROA during the pandemic highlights the risks associated with high leverage during economic downturns.

6.5 Inventory and Fixed Asset Management: The importance of Inventory Turnover and Fixed Asset Turnover increased during the pandemic, emphasizing the need for efficient asset utilization to maintain financial performance.

IMPLICATIONS FOR SUPPLY CHAIN RESILIENCE

The findings of this study have several implications for enhancing the resilience of the Malaysian retail food supply chain:

6.6 Proactive Risk Management: Businesses should adopt proactive measures to identify potential risks and develop contingency plans to mitigate the impact of future disruptions.

6.7 Diversification of Suppliers: Diversifying the supplier base and sourcing from multiple regions can reduce vulnerability to disruptions and ensure a more resilient supply chain.

6.8 Leveraging Digital Technologies: The use of digital technologies, such as blockchain, Internet of Things (IoT), and artificial intelligence (AI), can enhance supply chain visibility, agility, and collaboration, enabling businesses to respond swiftly to disruptions.

6.9 Sustainable Practices: Adopting sustainable practices, such as reducing waste, optimizing energy usage, and promoting environmentally friendly operations, can contribute to the long-term viability and resilience of the supply chain.

CONCLUSION

The study provides valuable insights into the impact of the COVID-19 pandemic on the Malaysian retail food supply chain. By analyzing financial data and developing predictive models, the research highlights the importance of

liquidity management, cost control, and operational efficiency in maintaining financial performance during disruptions. The integration of machine learning models into an interactive dashboard offers a powerful tool for stakeholders to enhance decision-making and improve supply chain resilience. The findings underscore the need for businesses to adopt proactive measures, such as diversifying suppliers, optimizing inventory, and leveraging digital technologies, to mitigate the impact of future disruptions and ensure the continuity of operations in the face of global challenges.

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