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Article

A comprehensive insight into manufacturing industry supply chain dynamics: A case study of the mosquito coil sector's challenges

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Abstract: This research explores the interactions within supply chains in the manufacturing sector, with a special emphasis on the distinctive obstacles encountered by the mosquito coil industry. The study is motivated by the need to comprehensively understand and address the multifaceted challenges encountered by manufacturers in their supply chain processes. The mosquito coil industry holds significant importance in Malaysia, primarily due to the country's tropical climate, which is conducive to mosquito proliferation and the transmission of mosquito-borne diseases. Nowadays, there are growing complexities and disruptions experienced by the mosquito coil sector's supply chain, prompting an in-depth investigation. The main objective is to identify the challenges and resilience strategies employed by manufacturers in this sector, providing an understanding that contributes to the broader discourse on supply chain dynamics. Employing a qualitative case study methodology, this research engages in extensive data collection through interviews, document analysis, and direct observations within the selected mosquito coil manufacturing entity. This methodology allows for an immersive exploration of the challenges faced, revealing insights into the factors influencing the supply chain dynamics. The study reveals a wide array of challenges, from obtaining raw materials to managing distribution logistics, underscoring the unique complexities specific to the sector. As a result, the research identifies and analyzes resilience strategies implemented by the mosquito coil manufacturer to mitigate challenges, such as procurement challenges faced in financial related issues, logistical complexities occurred from recent years' worldwide pandemic, production disruptions from company's human resource-related issues, global factors from the company's competitors and market challenges, and technology integration from rapid technological advancements. Thus, implications of this study extend beyond the mosquito coil sector, contributing valuable knowledge to the academic community, practitioners, and policymakers involved in supply chain management. The research not only addresses the identified challenges but also serves as a foundation for enhancing the overall understanding of manufacturing supply chain dynamics, thereby fostering informed decision-making for improved industry resilience.

Keywords: sustainable supply chain; Malaysian manufacturing industry; mosquito coil manufacturer; risk management; technological innovations

1. Introduction

In today's dynamic and interconnected global business environment, supply chain resilience has emerged as a critical factor for sustaining and thriving in the face of unprecedented disruptions (Narayanan et al., 2024a; Patel, 2023; Sivan et al., 2024a). The Malaysian manufacturing sector, a key player in the country's economic landscape, is no exception to the challenges posed by various uncertainties such as natural disasters, geopolitical tensions, and, most recently, the global health crisis (Alam et al., 2023; Koen et al., 2017). Recognizing the strategic importance of building resilient supply chains, this research endeavors to investigate and analyze the supply chain resilience strategies adopted by a prominent player in the Malaysian manufacturing sector—a mosquito coil manufacturer. The mosquito coil industry, an integral part of the Malaysian manufacturing landscape, faces multifaceted challenges, ranging from raw material procurement to distribution logistics (Sundram and Atikah et al., 2016). The objective of this case study is to explain the complexities of supply chain resilience in this particular context, highlighting the distinctive tactics utilized by the manufacturer of mosquito coils to manage disruptions and guarantee the uninterrupted supply of goods to the market.

As the global economy becomes increasingly interconnected, disruptions in one part of the supply chain can reverberate across the entire network, affecting production schedules, inventory management, and customer satisfaction (Mistarihi and Magableh, 2023). Understanding how a specific industry copes with these challenges is crucial for identifying best practices that can be applied more broadly within the manufacturing sector. In the case of mosquito coil industry, disruption in the raw material shortage that effect the production process, combating counterfeit products, addressing health concerns, adopting technological advancements, and aligning with consumer preferences are critical areas where the industry has made significant strides (Narayanan et al., 2024b; Poorni, 2021). By continuing to innovate and adapt, the industry can sustain its growth and contribute effectively to mosquito-borne disease prevention in Malaysia through a more resilient supply chain. This research, therefore, contributes to the academic discourse on supply chain management by providing insights into the resilience strategies employed by a Malaysian mosquito coil manufacturer, offering valuable lessons and recommendations for enhancing the overall resilience of the manufacturing industry in the region.

By exploring the real-world experiences of a mosquito coil manufacturer, this study aims to bridge the gap between theoretical frameworks and practical applications, offering an understanding of supply chain resilience in the Malaysian manufacturing context. Through the analysis of this case study, scholars, practitioners, and policymakers alike can glean actionable insights to fortify their own supply chains, ultimately fostering a more robust and adaptive manufacturing ecosystem in Malaysia and beyond.

2. Literature review

2.1. Mosquito coil industry

The mosquito coil industry has been experiencing notable developments recently,

driven by increasing demand due to rising mosquito-borne diseases and global warming, which provides favorable conditions for mosquito breeding. Globally, the mosquito repellent market, including coils, is projected to grow significantly, with a compound annual growth rate (CAGR) of about 5.65% from 2024 to 2032 (Fortune Business Insights, 2024). This growth is fueled by heightened awareness and governmental initiatives to combat mosquito-borne diseases such as dengue fever, malaria, and Zika virus.

In Malaysia, mosquito coils became popular due to the country's climate, which is conducive to mosquito breeding. Malaysian consumers prefer mosquito coils for their affordability and effectiveness. However, over the decades, the industry has evolved with advancements in insecticide formulations and manufacturing technologies. It is because, there is also a growing trend towards electric mosquito repellents and natural, non-toxic alternatives due to health concerns associated with prolonged exposure to synthetic chemicals in coils (Asia Society, 2021).

The regulatory environment in Malaysia can be burdensome, particularly with complex approval processes and stringent compliance requirements. This is due to the mosquito coil industry in Malaysia is regulated by the Ministry of Health and other relevant authorities to ensure product safety and efficacy. Although efforts have been made to streamline foreign investment approvals, regulatory hurdles still pose a challenge for the efficient operation of supply chains (Rodl and Partner, 2021; Sivan et al., 2024b).

In addition, with the increasing global emphasis on sustainability, the mosquito coil industry must navigate tighter environmental regulations and adopt greener practices. The Malaysian government has implemented frameworks like the National Industry ESG Framework to ensure industries comply with environmental standards, but adapting to these changes can be costly and complex (Aziz, 2024).

2.2. Supply chain resilience

Supply chain resilience has gained increasing attention in recent years as businesses across the globe grapple with the challenges posed by a volatile and interconnected environment. The literature on supply chain resilience provides a comprehensive understanding of the strategies, factors, and frameworks that contribute to building and sustaining resilient supply chains (Alqasa and Sundram, 2024; Mubarak et al., 2023; Selvaraju et al., 2017). In the context of the Malaysian manufacturing industry, where economic activities are closely tied to global markets, the imperative to enhance supply chain resilience becomes even more pronounced.

Supply chain resilience is a multifaceted concept with various definitions and dimensions. Christopher and Peck (2004) and Sharifi and Yamagata (2016) define resilience as the ability to "prepare and plan for, absorb shocks, recover quickly, and adapt in a changed environment." Additionally, Sheffi (2005) and Yang et al. (2024) introduce the concept of "flexible redundancy," emphasizing the importance of creating alternative pathways and redundancies within the supply chain to mitigate disruptions.

Effective supply chain resilience begins with a thorough understanding of risks and vulnerabilities. A study by El Baz and Ruel (2021) and Craighead et al. (2007)

explores the relationship between risk management practices and supply chain resilience, highlighting the importance of proactive risk identification, assessment, and mitigation strategies. The concept of vulnerability, as discussed by Pettit et al. (2019), underscores the need to address weak links in the supply chain that may amplify the impact of disruptions. Technological advancements play a pivotal role in enhancing supply chain resilience. Researchers like Chopra and Sodhi (2004) and Akhtar et al. (2022) emphasize the integration of real-time information systems to enable quick response to disruptions. Furthermore, Lee et al. (2017) argued that collaborative information sharing among supply chain partners fosters a culture of transparency and responsiveness, ultimately contributing to greater resilience.

Examining case studies provides valuable insights into how organizations have implemented and benefited from resilient supply chain strategies. A study by Raj et al. (2022) and Zsidisin et al. (2004) investigates the experiences of companies in managing supply chain disruptions, offering practical lessons and best practices. Such case studies contribute to the development of a contextual understanding of supply chain resilience, especially in the context of specific industries (Aljoghaiman and Sundram, 2023). Regional differences play an important role in shaping supply chain dynamics. In the Malaysian context, studies such as Abdul Wahab et al. (2015); and Atika et al. (2024) explore the challenges and opportunities specific to the manufacturing sector. Understanding the unique characteristics of the Malaysian manufacturing industry is essential for tailoring resilience strategies to the local context.

In summary, the literature on supply chain resilience provides a rich foundation for investigating the specific challenges faced by the Malaysian manufacturing industry, with implications for a mosquito coil manufacturer. This review highlights the interconnected themes of risk management, technological innovations, and regional perspectives, setting the stage for a detailed analysis of resilience strategies in the subsequent case study. The synthesis of these diverse insights contributes to a holistic understanding of supply chain resilience in the context of the Malaysian manufacturing sector.

3. Methods

3.1. Research design

This study adopted a qualitative research method that views the insights of reality as social construction process (Baškarada, 2014; Creswell and Clark, 2004). This research adopted case study approach to understand the challenges faced by supply chain managers from the insecticides industry in Malaysia. The adoption of the case study approach is prevalent in social science disciplines, particularly in organizational studies (Yin, 2014). It involves the examination of one or multiple organizations to observe and analyse the surrounding contexts and processes related to the phenomenon of interest (Hyett et al., 2014; Yin, 2014). Case study approach was adopted due to its nature that helps researcher deepen the understanding of the context in which the phenomenon is situated (Baxter and Jack, 2008; Gammelgaard, 2017; Yin, 2014). In case study approach, the selection of cases is crucial. While access is a common determining factor, it is essential to continually assess the suitability of the chosen

cases for the specific research at hand (Gammelgaard, 2017; Njie and Asimiran, 2014). Hence for this study, core business of the companies that has been selected as cases is related to mosquito coil production specifically. Multiple case studies have been adopted since it will increase the validity, precision, stability, and trustworthiness to findings (Miles et al., 2014; Yin, 2014).

3.2. Sampling

The purposive sampling strategy was used by selecting supply chain manager from three organization as a sample. It was applied because it can purposefully provide information and understanding of the research problem as well as the phenomena of interest (Sundram and Chandran et al., 2016). In gathering data, the researcher used a semi-structured interview approach as the main method. Semi-structure interview has been seen as the best method as it is flexible and not strictly confined to pre-formulated question in the protocol (Adeoye-Olatunde and Olenik, 2021). This method still allows researcher to follow-up questions and discussion by probing participants' responses and eliciting detailed information.

The interview session received greater participant engagement and involvement because the participants felt comfortable expressing their views and experience when given the opportunity to elaborate their responses (Alshenqeeti, 2014). The interview session with participants lasted more than 1 hour per session. Then, the analysis of interview transcribe has been done by using thematic content analysis. Thematic analysis is a widely used qualitative research method that involves identifying, analyzing, and reporting patterns or themes within a dataset (Vaismoradi et al., 2016).

Besides data from interview session, input from secondary document from the organization also has been analyzed by using the same approach. Additional data from multiple sources is important for triangulation. Triangulation in this study is crucial to improve the credibility and reliability of the findings by reducing bias and increasing robustness (Dzwigol, 2022). The data was analyzed within, and cross-case based on the emergent themes.

In conclusion, purposive sampling was used to select these managers, ensuring that the sample consisted of individuals who possess deep and relevant expertise. The three managers selected for the interviews were chosen based on their extensive experience and comprehensive knowledge of the supply chain dynamics within the mosquito coil manufacturing sector. These individuals hold key positions that provide them with an overarching view of the procurement, logistics, and production processes. Their insights are therefore highly representative of the challenges and strategies employed in the industry.

3.3. Background of cases

Case A: Manufacturer of mosquito coils (Mosquito coils sale market—Malaysia).

Japan is renowned for its world-leading insecticide technology. Company 1 (C1) is a multinational company from Japan in the Insecticide Industry since 1890. Since its inception in 1976 in Malaysia, C1 has established itself as "The expert in household pesticide products". They are well known for prioritizing creating effective, environmentally friendly, and safe innovations for all. C1 has long developed and

offered unique products as a key insecticide industry player. C1 has set up research and development centres in Japan, Indonesia, and Malaysia to enhance further the technologies and know-how, which are regarded as a front line in combating infectious diseases.

Case B: Manufacturer of mosquito coils (OEM manufacturer) (Mosquito coils sale market—for Export).

Company 2 (C2) manufactures OEM mosquito coils for the customer that are not able to produce mosquito coils. It has only one of its brands in the Malaysian market. C2 production specializes in producing mosquito coils to customer specifications, and most of its production is dedicated to OEM manufacturing. The company exports high-quality mosquito coils from Malaysia to Korea, Japan, and several other countries in Asia, Africa and South America.

Case C: Trading Company (Raw Material and Solution Supplier to mosquito coil manufacturer).

Company 3 (C3) is a Malaysia-based trading company (raw material, product, and services supplier to local manufacturers of mosquito coils in Malaysia and outside Malaysia manufacturing mosquito coils and incense). C3 is recognized as the one-stop solution and supply of Products and Services for companies manufacturing mosquito coils. C3 specializes in mosquito coil formulations and procurement of raw materials used to produce mosquito coils. As a result, C3 attained the unique position of being the best outsourcing company in specialized commodities, including public health chemicals, insecticides and pesticide chemicals, food and fragrance and essential oils. In addition, C3 has established collaboration with manufacturers and brand owners in developing customized products. C3 is well-known in the mosquito coil manufacturing community for its raw material supply management expertise.

4. Results

Table 1. Thematic analysis of the challenges faced by supply chain manager in mosquito coil manufacturing company.

Themes	Sub-themes	Codes
Internal factors challenges	Customer satisfaction	• Packaging • Product quality • Pricing • Delivery period
	Production related issues	• Raw materials related issues • Inventory management • Need for R&D in production
	Financial related issues	• Operation cost increase • Revenue affected due to many issues
	Human resource related issues	• Work quality • Lack of skills and knowledge • High turnover • Shortage of labour • Competency of the workers

Table 1. (*Continued*).

Themes	Sub-themes	Codes
External factors challenges	Global pandemic (Covid19)	• Delayed deliveries • Limited availability of resources • Supply chain limitations • Clearance and transportation issues
	Political factors	• Trade restriction • Regional conflicts • Political instability • Export/import regulations • International sanctions

Based on the thematic content analysis that has been conducted, the result of this study focuses on the challenges faced by supply chain managers in mosquito coil manufacturing companies. The data analysis raised two major themes and several sub-themes as shown in **Table 1**.

4.1. Theme 1: Internal factors challenge

This study has identified that challenges related to internal factors are the most critical ones faced by supply chain managers in the Mosquito Coil Manufacturing sector. Five sub-themes related to the functional areas of the company have emerged under Theme 1.

4.1.1. Sub-theme: Customer satisfaction

The findings highlight that managing customer expectations, especially regarding customer satisfaction, poses a significant challenge among the internal factors. Managers from all three case studies have identified meeting customer expectations concerning product quality as their most formidable challenge. As expressed by the supply chain manager from Company 1 (C1): “It is very challenging for us, especially when customers demand high quality in mosquito coils. They compare the burning duration of our coils with what we have advertised, claiming that the actual burning time is less.”

Similarly, managers from Companies 2 and 3 (C2 and C3) have frequently mentioned the difficulty in meeting the high standards customers expect for coil quality. The repercussions of not meeting these expectations are severe. This issue is exacerbated when customers demand high-quality products at low prices. As one manager stated: “If any standard of the coil is not met, they will reject the entire batch, which is extremely difficult for us. Imagine, they desire high-quality coils but want to pay a low price. If we don’t offer them a low price, they threaten to end the deal.”

Packaging issues have also been a point of contention, as reported by managers from Companies 1 and 2 (C1 and C2). Complaints have arisen over unattractive packaging. Additionally, there is an expectation for mosquito coils to be packaged and loaded onto pallets before container loading. This requirement poses a logistical challenge, reducing the number of products that can be shipped per consignment. The challenge of meeting customer shipment expectations was also highlighted by the manager from Company 3 (C3), who pointed out, “Customers expect the delivery of raw materials or products to be on time, yet they place orders late.” Furthermore, “at times, customers demand urgent delivery of goods, earlier than the initially agreed

delivery period." These observations underscore the daunting task of fulfilling customer expectations, which significantly impacts the company in terms of increased costs and commitment to delivery times.

4.1.2. Sub-theme: Production-related issues

Production-related issues have been identified as a challenge by the manager of the mosquito coil manufacturer. A primary challenge in production faced by the Supply Chain (SC) manager from all three cases is the handling of raw materials. As a mosquito coil manufacturer, certain raw materials, such as binder agents, are not locally available in Malaysia. Consequently, SCM must coordinate procurement by importing starch powders from Vietnam, Indonesia, and Pakistan. This situation has led to inconsistent raw material quality issues. A common problem arises when the consignment arrives, and the starch powder quality is inferior to the required standard. "Q.C. has tested the sample from the supplier earlier (before ordering), and it was okay and met the standard. Unfortunately, the quality of the starch we receive (upon arrival) is poor. If the gum strength is low, it will affect the product quality." The low-strength coil would result in high breakages in mosquito coils. Consequently, the production formulator needs to increase the starch powder usage to meet the viscosity standard required, increasing production costs that the company must bear. In other cases, the SC manager shared that some customers prefer to appoint their Q.C. person to assist in-house Q.C. in assessing the quality of raw materials. "The raw material that was approved will be kept separately to produce the customer's coil only. We must coordinate the various grades of raw material quality based on the customer's requirement."

In addition to raw material quality, the SC manager from C2 and C3 raised issues regarding the quantity of the raw materials received from the supplier. "We also have problems with shortages in the quantity of goods delivered to us." A shortage of the raw materials received will interrupt production, delay customer orders, and increase costs.

Another challenge in mosquito coil production is inventory management. All the SC managers from three cases highlight the crucial need for effective inventory management of raw materials and end products in the warehouse. They agree on the need to calculate and ensure the warehouse has enough space to store the raw materials. "As I mentioned, our raw materials are natural-based, so we (SCM) need to be careful, not only in procurement but also in how to store them accordingly." Inventory management becomes challenging when customers specifically select raw materials according to the quality they want. Specific raw materials need to be stored separately from other materials. As the manager claimed, "Due to this, we need to ensure workers check the stock level separately and never use it (raw materials) for other coil production." Meanwhile, the SC manager from C3 emphasizes the challenge of inventory management from the customer's inventory perspective. As a supply chain manager, they must regularly monitor the customers' end raw material stock levels. This is very important to avoid shortages or last-minute orders. Additionally, SCM needs to track whether the customer uses the material within the stipulated time to maintain quality. However, the challenge arises when customer workers sometimes provide incorrect information. "If they provide us with wrong information, it will lead

to issues with production formulation."

On a different note, the SC Managers from all three cases also reported that the company faces challenges in Research & Development matters related to mosquito coil production. More R&D is needed, especially to test the efficacy of the active ingredient used in mosquito coil production. Currently, the manufacturer has a limited scope of raw materials that can be used in mosquito coil production. "We have a limited type of starch powder that can be used to produce coils."

4.1.3. Sub-theme: Financial-related issues

Due to the Covid-19 pandemic in 2020, Mosquito Coil manufacturers faced financial challenges as most buyers limited their purchases to essentials. Additionally, Supply Chain (SC) managers from Case A and B acknowledged that customers were demanding longer credit terms. "We have to fulfill the demand, or we will lose them," stated the SC manager from Case A. This request for extended credit terms is attributed to the financial condition of the customers, as explained by the SC manager from Case A: "It's a domino effect. They are having a tough time, which in turn affects us," echoed the SC manager from Case B. On another note, all SC managers agreed that financial matters are challenging due to increasing operational costs, including hikes in electricity, labor, and raw material costs. "We can't escape the rising costs," they agreed, noting that this reduces profit margins, leading to financial struggles. "Everything is expensive nowadays, including labor." The government's announcement of a rise in the minimum salary cap has also contributed to the increasing labor costs that the company must contend with.

4.1.4. Sub-theme: Human resource-related issues

Table 2 shows that human resource issues have been identified as one of the most significant challenges faced by SC managers. The challenges include work quality, a lack of skills and knowledge among employees, high turnover, and a labor shortage.

Table 2. Thematic analysis of human resource-related issues encountered by the SC Managers.

HR Challenges	Examples of quotes	Case
Work quality	"Some workers are not consistent, it effects the work quality" "They do not perform, the quality of their work turns bad"	A, B
Lack of skill and product knowledge	"They don't know how to solve small issues in the production" "The labour has lack of skill in the production" "We have to admit, we have lack of skilled labour especially during the Covid-19" "The workers just know little bit about the product"	A, B, C
High turnover	"Production operation are highly dependent on foreign workers, but we have issues to retain them" "It not easy to maintain the number of staff."	A, B
Shortage of labour	"Due to high turnover, we have problem on number of staff" "Due to the small team size, some of them take medical or annual leave, it disrupts the workflow"	A, B, C

4.2. Theme 2: External factors challenge

Two emerging themes have emerged as sub-themes under the external factors challenges faced by a supply chain manager at a mosquito coil manufacturer. There is a global pandemic (COVID-19) and political factors.

4.2.1. Sub-theme: Global pandemic (COVID-19)

The COVID-19 pandemic that struck in 2020 has been a major global challenge for mosquito coil manufacturers. The pandemic has forced manufacturers to grapple with numerous difficulties, including delayed deliveries, limited availability of resources, supply chain constraints, and clearance and transportation issues. As the Supply Chain (SC) manager from Case A indicated, delivery delays have disrupted production plans, often due to raw materials needed for production not arriving on time. SC managers from Cases B and C expressed similar concerns, as delivery delays have caused significant problems in mosquito coil production. "We must keep waiting. The delays disrupt our production line," stated the SC manager from Case A. The delayed deliveries of raw materials have led to resource scarcity. Additionally, the workforce numbers fluctuated, with many workers affected by COVID-19. Due to illness and the quarantine measures required by the government, the company experienced a shortage of workers. This situation impacted the supply chain due to production capacity issues. "Clearance and transportation from the seaport to the factory have been delayed due to the Movement Control Order (MCO)," claimed an SC manager, noting that the MCO hindered the clearance process for products. **Table 3** below presents the findings related to the challenges caused by the COVID-19 pandemic.

Table 3. Challenges related to the COVID-19 pandemic.

Challenges due to Covid-19	Impact
Delayed deliveries	• It has disrupted production plans
Limited availability of resources	• Need to adjust the production line to only certain mosquito coils SKU's. • Lack of human resources due to illness and quarantine measures
Supply chain limitations	• It has impacted the production capacity.
Clearance and transportation issues	• Disrupt the document submission to bank due to MCO.

4.2.2. Sub-theme: Political factors

Another significant challenge related to external factors, as mentioned by all managers, is political influences. The SC Manager from Case A discussed the trade restrictions in 2018 involving the trade war between the United States and China, which imposed tariffs on a wide range of products. If Malaysia imports significant quantities of mosquito coil raw materials from China and exports finished coils to the United States, these trade restrictions could increase costs or limit market access, disrupting the supply chain. The manager from Case A emphasized, "Suddenly, these limitations can severely disrupt the supply chain of mosquito coils, as manufacturers may struggle to procure enough raw materials to meet demand."

In addition to trade restrictions, issues such as regional conflict have been highlighted by all SC managers across the three cases. "Have you ever considered how a conflict or political unrest in neighboring countries like Indonesia or Thailand could impact Malaysia's mosquito coil supply chain?" asked the SC manager from Case B, adding that disruptions in transportation routes, such as ports or roads, could delay the importation of raw materials or affect the distribution of finished coils to the market,

significantly impacting mosquito coil producers in Malaysia. Beyond the aforementioned challenges, factors such as political instability, particularly in Malaysia, also indirectly affect the industry. Malaysia experienced a notable political shift with a new government assuming office in 2018. Such political transitions can introduce uncertainties and policy changes that may affect the regulatory environment for mosquito coil manufacturing. "Changes in regulations or policies can disrupt the supply chain and manufacturing operations, leading to delays or disruptions in mosquito coil availability."

SC managers from Case B and C confirm that government-imposed export and import regulations present challenges for mosquito coil manufacturers. For instance, the introduction of new, stricter regulations or standards for mosquito coil imports to ensure product safety and quality could pressure manufacturers to comply. As the SC manager from Case B put it, "If the government decides to impose more stringent regulations or higher quality standards for mosquito coil imports, it could significantly affect both manufacturers and the supply chain." The SC manager from Case C suggested, "Consider that manufacturers would likely need to make substantial changes to their production processes, potentially requiring new equipment investments, formulation alterations, or manufacturing practice adjustments to meet the new quality standards." The introduction of stricter rules and regulations will undoubtedly increase production costs. However, the impact is not solely financial; production delays, process reconfigurations, and certification can also lead to supply chain disruptions. "Delays in production, process reconfiguration, and undergoing certification can disrupt the supply chain, potentially affecting the industry's ability to meet demand and the availability of mosquito coils on the market," stated the SC Manager from Case B.

On a different note, the SC manager from Case A expressed concerns about challenges related to international sanctions. Such measures are typically employed to encourage the target country or entity to alter its behavior, often in response to actions or policies deemed harmful or in violation of international standards. The SC manager from Case A noted the potential severity of this issue, "If Malaysia is targeted by international sanctions from the United Nations due to political or human rights issues, it can restrict trade and financial transactions, making it difficult for manufacturers to import raw materials or export finished products." It's essential to recognize that the effectiveness of international sanctions can vary greatly, and their impact on the targeted country's conduct and the welfare of its citizens can be contentious.

5. Discussion

The findings presented in this study offer a comprehensive examination of the supply chain dynamics within the unique context of the mosquito coil manufacturing sector. The challenges identified demonstrate the complex interaction of factors that affect the entire supply chain, including procurement and distribution. This discussion explores the key insights derived from the case study and explores their implications for the broader manufacturing industry.

5.1. Theoretical implications

Firstly, the procurement challenges faced in financial related issues, and the companies' public and private partnership. The study reveals that the mosquito coil sector faces notable challenges in procuring raw materials. These challenges stem from both internal and external factors, such as fluctuations in the availability and pricing of essential ingredients. The discussion underscores the significance of strategic procurement planning to mitigate these challenges and ensure a stable supply of materials.

Secondly, the logistical complexities occurred from recent years' worldwide pandemic. Logistics emerged as a critical bottleneck within the mosquito coil supply chain. The study highlights issues related to transportation, warehousing, and distribution that significantly impact the overall efficiency of the supply chain. The COVID-19 pandemic highlighted vulnerabilities in global logistics, with transportation disruptions affecting the timely delivery of raw materials and finished products. This prompts a discussion on the need for advanced logistical solutions, including technology-driven tracking systems and streamlined distribution networks.

Thirdly, production disruptions came from internal factors in the company's human resource-related issues, such as workforce skills and workplace conditions. The case study identifies disruptions in the production process, often attributed to unforeseen factors such as machinery breakdowns or fluctuating workforce availability. Discussing these production challenges emphasizes the importance of contingency planning and implementing agile manufacturing practices to enhance adaptability to dynamic conditions.

Another would be the impact of global factors from the company's competitors and market challenges. The interconnectedness of the mosquito coil industry with global markets exposes it to externalities, such as geopolitical tensions or international supply chain disruptions. This discussion underscores the importance of understanding and mitigating the impact of global factors on local supply chain dynamics, necessitating a holistic approach to resilience planning.

Lastly, the technology integration from rapid technological advancements requires manufacturers to continuously upgrade their production processes and product offerings. The study emphasizes the role of technology in mitigating supply chain challenges. Collaborative information sharing and real-time data integration are identified as strategies to enhance responsiveness and transparency. The discussion explores the potential benefits of further integrating technology into the supply chain, emphasizing its role in building resilience and improving overall efficiency.

5.2. Practical implications

Resilience strategies in the mosquito coil industry profoundly influence supply chain management. Given the industry's reliance on raw materials like pyrethrum, citronella, and various binders, disruptions in the supply chain can have severe ramifications. Implementing resilience measures involves diversifying sourcing channels, establishing robust supplier relationships, and developing contingency plans for unforeseen events such as natural disasters or geopolitical tensions. By doing so, companies can mitigate risks and ensure a steady flow of materials, thereby

safeguarding production capabilities and meeting market demands.

Furthermore, embracing technological advancements like predictive analytics and blockchain can enhance supply chain visibility and traceability. Real-time data analytics enable proactive decision-making, allowing companies to identify potential bottlenecks and optimize inventory management. Meanwhile, blockchain technology ensures transparency and accountability throughout the supply chain, reducing the risk of counterfeit products and enhancing consumer trust.

Moreover, resilience strategies entail engaging with stakeholders to foster sustainable practices across the value chain. Collaboration with local communities, government agencies, and non-profit organizations facilitates knowledge sharing and capacity building. Through collective action, the mosquito coil industry can address complex sustainability challenges and contribute to the broader goal of environmental conservation.

Therefore, the impact of this study extends beyond the mosquito coil sector, providing valuable insights for practitioners, policymakers, and scholars in the broader manufacturing industry. By comprehensively examining the challenges within the mosquito coil supply chain, the study contributes to a deeper understanding of how industry-specific factors interact with general supply chain principles. Practically, the findings offer actionable recommendations for stakeholders within the mosquito coil sector to address specific challenges and enhance their supply chain resilience.

Policymakers can leverage these insights to formulate industry-specific policies that foster a more robust and adaptable manufacturing ecosystem. Scholars benefit from this research by gaining an understanding of how supply chain dynamics manifest in a sector with unique characteristics. This study lays the groundwork for future research endeavors focused on refining resilience strategies and exploring the transferability of these strategies to other manufacturing domains. In conclusion, the comprehensive insights provided by this study illuminate the complexities of supply chain dynamics within the mosquito coil sector, offering practical implications and contributing to the broader discourse on manufacturing supply chain resilience.

6. Conclusion and recommendation

In conclusion, this study provides a thorough exploration of the supply chain dynamics inherent in the mosquito coil manufacturing sector, shedding light on the challenges that significantly impact the industry's operational efficiency. The multifaceted challenges identified across procurement, logistics, production, and global influences underscore the complexity of the supply chain within this niche sector. The interconnected themes of technology integration and the impact of global factors further emphasize the need for a holistic approach to resilience planning. The findings of this case study not only contribute to an understanding of the mosquito coil sector but also hold broader implications for the manufacturing industry at large. The identification and analysis of challenges offer valuable insights for practitioners and policymakers seeking to enhance their supply chain resilience strategies in the face of a dynamic and interconnected global landscape.

In order to bolster supply chain resilience within the mosquito coil manufacturing sector, a set of strategic recommendations emerges. Firstly, it is imperative to develop

and implement a robust procurement strategy that accounts for the dynamic availability and pricing of raw materials, with a focus on establishing long-term partnerships and diversifying sources to enhance stability. Secondly, investing in advanced logistical solutions, including technology-driven tracking systems and optimized distribution networks, is crucial to improving efficiency and mitigating disruptions in transportation, warehousing, and distribution. Thirdly, the sector should prioritize comprehensive contingency planning for production disruptions, encompassing agile manufacturing practices and preventive maintenance to minimize downtime and ensure seamless production processes. Additionally, a dedicated risk management strategy must be developed, considering the influence of global factors on the local supply chain. Regular monitoring of geopolitical situations and international disruptions, coupled with proactive measures, is essential to manage potential risks effectively. Furthermore, the integration of technology into the supply chain through collaborative platforms and real-time data sharing is paramount for enhancing transparency, responsiveness, and communication among supply chain partners, ultimately contributing to greater resilience.

Lastly, fostering cross-industry collaboration and knowledge-sharing across manufacturing sectors is encouraged, establishing forums for the exchange of best practices and innovative solutions to address common challenges in supply chain management. These recommendations collectively serve as a comprehensive framework to fortify the mosquito coil manufacturing sector's supply chain resilience. These recommendations serve as a practical guide for stakeholders within the mosquito coil sector and the broader manufacturing industry, providing actionable steps to fortify supply chain resilience. For example, by diversifying suppliers and improving supply chain logistics, manufacturers can avoid production halts due to raw material shortages or transportation disruptions. Also, government and regulatory bodies erect public health protection guidelines in order to ensure that the mosquito coils available in the market are safe for public use, reducing health hazards. Additionally, in favor on investors and shareholders for ensure a steady return on their investments through consistent business performance and profitability from the stable company's growth. By implementing these measures, practitioners can navigate the identified challenges more effectively, ultimately contributing to a more resilient and adaptive manufacturing ecosystem.

6.1. Limitation of study

Several limitations occurred from conducting this study. The major obstacle would be the inconsistency in responses from a one-on-one interview. Furthermore, interviews often rely on self-reported data, which can be influenced by the respondent's memory, honesty, and willingness to disclose information. Moreover, the availability of comprehensive and up-to-date data on the mosquito coil industry, particularly in Malaysia, can be limited. Due to lack of longitudinal studies may hampers the ability to observe long-term trends and the effectiveness of resilience measures over time. Many studies focus on broader mosquito repellent markets or specific aspects like health impacts, leaving gaps in industry-specific data. Additionally, research often generalizes findings from global or regional studies,

which some may disparate when compared to the Malaysian context due to local market conditions, regulatory environments, and consumer behavior. Other than that, the inadequate involvement of relevant stakeholders that may miss certain critical perspectives. Also, non-transparent research methods may raise questions about the validity of findings, such as stakeholders may be less likely to adopt strategies based on opaque research.

6.2. Future research

Develop frameworks that incorporate methodologies from existing resilience frameworks such as the Supply Chain Operations Reference (SCOR) model and adapt them to the mosquito coil industry context. Focus on risk assessment, response strategies, and recovery planning. Another recommendation would be by conduct surveys and focus groups to gather data on consumer preferences to investigate changing consumer preferences and trends in mosquito coil usage. Also, implement risk assessment frameworks such as Failure Modes and Effects Analysis (FMEA) to systematically identify and evaluate risks. Thus, develop mitigation strategies for high-priority risks. Lastly, future research on the mosquito coil industry supply chain should focus on comprehensive analysis, technological advancements, regulatory impacts, market dynamics, risk management, collaboration, and ESG integration. By addressing these areas, researchers can provide actionable insights that enhance theoretical understanding and practical applications, ultimately contributing to a more resilient and sustainable mosquito coil industry.

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