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The Role of Business Continuity Management in Supply Chain Resilience in Comparison between Manufacturing and Service Industries: Empirical Evidence from Thailand

Baweena Ruamchart
Logistics Management Department, Faculty of Management Sciences, Kasetsart University, Thailand
Email: baweena.r@ku.th

Tanutpats Dhiratanuttdilok
Logistics Management Department, Faculty of Management Sciences, Kasetsart University, Thailand
Email: tanutpats.d@ku.th

Kusuma Piriyapun
Logistics Management Department, Faculty of Management Sciences, Kasetsart University, Thailand
Email: kusuma.pi@ku.th (*Corresponding Author*)

ABSTRACT

Business Continuity Management (BCM) plays a critical role in an era of uncertainty and crisis events. Supply Chain Resilience (SCRES) enables organizations to respond rapidly to disruptions. This study aimed to (1) examine the relationship between BCM and SCRES, (2) compare the structural and contextual differences between manufacturing and service sectors in terms of crisis responses, and (3) validate the proposed BCM–SCRES model with real-world business operations in the manufacturing and service industries. A mixed-methods approach was applied in this study. For the quantitative study, data were gathered from 434 organizations across the manufacturing and service sectors. The data were then analyzed using Structural Equation Modeling (SEM). The proposed model was subsequently validated through in-depth interviews involving three business cases. The findings revealed that BCM had a direct and significant impact on SCRES. When comparing the role of BCM in SCRES between manufacturing and service industries, the Recovery Plan (RP) emerged as the most critical component, followed by Crisis Management (CM) in both sectors. For the manufacturing industry, the Business Continuity Plan (BCP) placed third in importance, whereas it held fourth place in the service industry. Conversely, Emergency Management (EM) had the lowest influence in the manufacturing sector but held greater significance in the service sector, where it ranked third. Qualitative validation confirms that these relationships are reflected in organizational practices. These findings not only enhance the long-term recovery capacity of these sectors but also strengthen the sustainable international competitiveness of Thailand's manufacturing and service industries.

Keywords: *business continuity management; supply chain resilience; recovery plan; crisis management; emergency management, business continuity plan*

1. INTRODUCTION

Today's business world is marked by uncertainty due to the rapidly changing and unpredictable environment of the current era of VUCA (volatility, uncertainty, complexity, and ambiguity) (Raghavan *et al.,* 2025). These challenges include the global disruptions caused by the COVID-19 pandemic, semiconductor supply shortages, geopolitical realignments in international trade policies, and escalating political tensions involving both diplomatic disputes and military conflicts. Moreover, the continued Russia–Ukraine and the Israel–Hamas conflict has contributed to greater global instability, affecting economies and diplomatic relations around the world. At the beginning of 2025, trade policy tensions between two superpowers, the United States of America and China, has affected not only those countries' economies but the global economy and global supply chains. Furthermore, the world is confronted with increasingly frequent and severe natural disasters such as wildfires, hurricanes, and earthquakes. They also have a significant impact on exports, imports, and investment (SETInvestNow, 2025).

These disruptions have profoundly affected global logistics infrastructure, impacting both domestic and international transportation networks as well as production systems. Industries relying on just-in-time delivery models and maintaining minimal resource reserves have proven particularly vulnerable to these shocks (Department of International Trade Promotion, 2024). Consequently, manufacturing and service sectors worldwide face multifaceted challenges including labor and raw material shortages, production slowdowns, energy supply chain disruptions, and substantial operational backlogs resulting from persistent global logistics delays (Naz and Kear, 2022; Liu, 2024; Guo *et al.,* 2025; Xu, Elomri, Kerbache & El Omri, 2020).

From 2019 to 2022, the overall state of Thai industries became increasingly fragile. Thailand experienced a growing number of business closures in both manufacturing and

service industries, primarily attributed to the lingering effects of COVID-19 and evolving customer demands (Leurcharusmee *et al.,* 2022; United Nations Industrial Development Organization, 2021). The year 2021 marked the beginning of an accelerated structural crisis in Thailand's manufacturing and service sectors. Since the outbreak of COVID-19, factory closures have continued to rise steadily over the past several years, with the manufacturing sector in particular experiencing contractions of 2.7 percent and 0.5 percent in 2023 and 2024, respectively. These developments have significantly undermined Thailand's overall competitiveness (Thai PBS, 2025). In addition, these closures predominantly affected small and medium-sized enterprises (SMEs), which are particularly vulnerable to production cost fluctuations and market demand volatility due to structural weaknesses in the supply chain system. Consequently, the Thai business sector demonstrated limited flexibility in responding to these unprecedented challenges.

Additionally, various industries in Thailand have experienced severe supply chain disruptions. The absence of business continuity management (BCM) planning in logistics management structures and the lack of integrated risk management mechanisms among upstream, midstream, and downstream organizations have caused significant disruptions across multiple sectors, particularly in the automotive supply chain (Kato and Charoenrat, 2017; Navavongsathian *et al.,* 2020). These disruptions have affected every stage of the supply chain, from suppliers and manufacturing to distribution, retail, and service industries. Thailand's experience demonstrates how supply chain vulnerabilities can cascade throughout entire networks when comprehensive BCM planning is absent. Disruptions have been felt at all levels, from raw material sourcing to final product delivery. Furthermore, any disruption in upstream raw material supplies can trigger downstream order cancellations or unexpected demand surges (Gupta *et al.,* 2021).

These challenges underscore the critical importance of enhancing supply chain resilience through effective business continuity management systems. In the current volatile environment, BCM has evolved into a strategic mechanism essential for developing organizational resilience, operational flexibility, and competitive advantage during crisis situations (Fiksel and Croxton, 2010).

From the existing literature, it is evident that the relationship between BCM and SCRES in crisis management remains inadequately understood. Awang Ali *et al.* (2023) noted that most organizations lack an integrated approach to developing BCM strategies that systematically strengthen SCRES. This observation aligns with Pettit *et al.* (2010), who emphasized that BCM and SCRES have predominantly been studied in isolation, with limited research systematically integrating these two concepts within the same analytical framework. There is still a lack of studies that have examined BCM and SCRES simultaneously across both manufacturing and service industries. Furthermore, most existing research has focused on developed countries, leaving substantial gaps in empirical evidence from developing economies. Notably, no comparative analysis has been conducted between manufacturing and service industries specifically in the Thai context. This presents a significant research opportunity to examine the BCM-SCRES relationship during crisis situations in a developing country setting.

Therefore, this research aims to: (1) examine the relationship between BCM and SCRES by identifying the key BCM components that significantly influence supply chain resilience, (2) compare the structural and contextual differences between manufacturing and service sectors in terms of crisis responses, and (3) validate the proposed BCM–SCRES model with real-world business operations in the manufacturing and service industries. The findings contribute to integrating BCM into national logistics and supply chain infrastructure policies, including investment planning, workforce development, and the design of distribution centers equipped for rapid and effective crisis recovery.

2. LITERATURE REVIEW

Previous studies related to the manufacturing and service sectors, highlighting their differences in operational processes and value creation, and identifying key factors that influence organizational competitiveness and resilience. The relevant literature is reviewed as follows.

2.1 Overview of Manufacturing and Service Industries

The global industrial economy comprises two principal sectors: manufacturing and services. These sectors exhibit fundamental differences across multiple dimensions, including production methodologies, output characteristics, resource requirements, and value creation mechanisms for customers.

2.1.1 Manufacturing Industry

The manufacturing industry encompasses systematic physical and mechanical processes that transform raw materials into finished products through structured planning and control systems within production facilities (Groover, 2020). This transformation involves multiple stages that convert raw materials into products with enhanced economic value (Zhong *et al.,* 2017).

Supply chain recovery in manufacturing refers to organizational-level activities that restore production and distribution operations to normal or enhanced performance levels following major disruptions such as natural disasters, pandemics, or supply chain breakdowns (Ponomarov and Holcomb, 2009).

Recent scholarly contributions have proposed various recovery approaches. Paul and Chowdhury (2020) advocated capacity planning and emergency warehousing strategies to mitigate operational uncertainties, while Ivanov (2021) recommended agent-based modeling for developing post-crisis production strategies. These theoretical advances have translated into practical investments, with manufacturing companies upgrading their planning and response capabilities through advanced planning systems (McKinsey and Company, 2024). Deloitte (2024) found that 78% of manufacturers have invested or plan to invest in supply chain planning software, leveraging big data and advanced analytics to enhance supply chain flexibility and efficiency. Furthermore, Capgemini (2025) reported that UK organizations plan to invest $650 billion in reshoring and nearshoring initiatives to strengthen resilience and mitigate future supply chain disruption risks.

2.1.2 Service Industry

The service sector is the part of the economy that produces intangible goods. This includes retail, logistics, finance, education, health, and tourism.

The COVID-19 pandemic severely impacted global hospitality supply chains, particularly in the tourism sector. Efthimiou (2025) reported that international travel demand fell by 73% from pre-pandemic levels, domestic travel by 34%, and overall international travel by 69%. In 2023, research by Zahan and Al-Amin (2025) indicated that designing post-COVID-19 recovery strategies for the tourism and hospitality industry requires changes in consumer behavior, the adoption of technology, and adherence to health and safety measures. Although travel restrictions were gradually lifted, travel demand in 2021 remained significantly lower than pre-pandemic levels, indicating that travelers had not yet regained full confidence in traveling (European Travel Commission, 2021).

Research by Matijević *et al.* (2025) emphasized the importance of stakeholder collaboration in developing and implementing tourism industry recovery strategies, using the "3R" framework: Recognize, Rationalize, and Refashion. Organizations have been continuously developing and adapting strategies to increase the resilience and recovery of their supply chains.

2.2 Research on VC and Enterprise GI

BCM is a comprehensive management process that identifies potential threats to an organization and assesses their impact on business operations, while providing a framework for building organizational resilience and effective response capabilities. The primary goal of BCM is to enable organizations to maintain critical operations during disruptions or restore normal functionality within minimal timeframes. This process encompasses threat identification, impact analysis, and the development of strategic measures to enhance organizational resilience and ensure effective responses to diverse crisis situations.

BCM encompasses both proactive strategies that shape organizational resilience (such as Business Impact Analysis and Risk Assessment) and reactive measures that address immediate crisis situations (including contingency planning, crisis communications, and disaster recovery protocols). These practices collectively aim to protect stakeholder interests, preserve organizational reputation and public image, and maintain the organization's capacity to generate business value during and after disruptive events (Gibb and Buchanan, 2006).

Awang Ali *et al.* (2023) found relationships between continuity management, organizational resilience, and operational performance in SMEs. Additionally, Gibb and Buchanan (2006) observed that BCM research trends continuously evolve across various dimensions, including information technology management, cybersecurity, supply chain management, and natural disaster response, indicating the necessity of BCM in today's highly uncertain and volatile business environment.

Research by Garvey *et al.* (2023) emphasized the role of ISO 22301:2021, the latest industry standard for supply chain continuity management, in enhancing response and recovery capabilities among key suppliers to strengthen adaptability and responsiveness to unexpected events. Furthermore, implementing ISO 22301 supports organizations in sustaining critical operations during times of adversity. Moreover, Riglietti (2022) emphasized that integrating ISO 22301 standards into corporate strategic planning not only enhances business operational flexibility but also mitigates supply chain risks. This integration necessitates a strong emphasis on training, awareness-building, and the continuous improvement of Business Continuity Management Systems (BCMS).

Furthermore, the study of Uraipan *et al.* (2020) that was conducted in Thailand found that the integrated BCM structure consisting of four main parts: Business Continuity Planning (BCP), Recovery Plan (RP), Crisis Management (CM), and Emergency Management (EM). These components form the foundation of organizational recovery during crises and are discussed in both research and practices of public and private sector organizations (Foster Fuels, 2025; Kingsbridge BCP, 2025). The details are as follows:

2.2.1 Business Continuity Planning (BCP)

Implementing BCM offers various organizational benefits (Russo and Reis, 2020). One of the key outputs of BCM is the BCP, which is developed to avoid or mitigate potential risks. It also involves resource planning to ensure that critical business functions can be maintained during disruptions (Hughes, 1985). The process begins with a Business Impact Analysis (BIA), risk assessment, and recovery strategy development before implementing the plan (Watters, 2013). Fani and Subriadi (2019) emphasize that a flexible and regularly updated BCP improves organizational recovery. Similarly, Kato and Charoenrat (2017) found that Thai SMEs adopting BCM face resource constraints but benefit from context-specific and sector-based approaches to enhance resilience.

In Thailand, organizations have increasingly adopted BCP. Thailand Post was certified under ISO 22301 in 2017 (Office of Academic Resources, 2017). JAS Asset applied BCP to various crises (JAS Asset, 2025), while the Cooperative Auditing Department used BCP during COVID-19 to adjust systems and priorities (Office of Academic Resources, 2021). These cases reflect diverse applications of BCP toward resilience and preparedness.

2.2.2 Recovery Plan (RP)

As part of the BCP process, disaster recovery focuses on the IT systems, technology infrastructure, and data that require restoration following a disaster or service disruption affecting the business. By implementing robust recovery procedures, businesses can minimize downtime and restore services efficiently, ensuring long-term operational continuity (Hughes, 1985).

2.2.3 Crisis Management (CM)

CM refers to the processes that organizations use to coordinate responses to disruptive events, with the objective of minimizing damage and ensuring organizational survival. This includes managing incidents at the site level and transitioning to business continuity teams for recovery (Fischer *et al.,* 2019; Hughes, 1985). Successful crisis management depends heavily on preparatory planning and simulation-based exercises that provide teams with the knowledge and readiness needed to respond effectively to real-life situations. By simulating potential crises, organizations can reduce disruptions and build greater overall resilience (Fischer *et al.,* 2019).

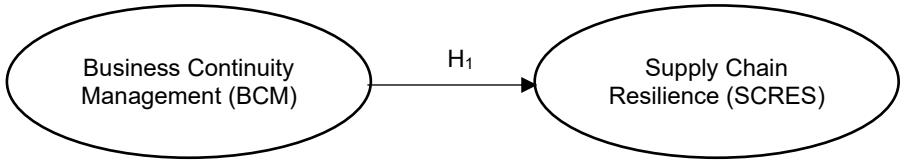

Figure 1 Conceptual Framework of this Study

Thailand has implemented comprehensive crisis management frameworks following international best practices. The country has utilized the Incident Command System (ICS) to manage various types of disasters, including the COVID-19 pandemic. Under this system, the Public Health Emergency Operations Center (PHEOC) oversees operational management, command and control functions, and response coordination, including surveillance, assessment, and inter-agency coordination (Khingchatturat *et al.,* 2024).

2.2.4 Emergency Management (EM)

The response just for the emergency response is the immediate response at the site where the disaster occurs, industrial accidents and natural calamities, and so on. Serving as a barrier in the first line of defense are the measures that are directed to protect from damage to ensure safety (Fischer *et al.,* 2019). Additionally, the study by Smith and Brooks (2013) underscores the value of proactive readiness, stressing that all organizations ought to develop a structured emergency response plan to enable a rapid and appropriate response to a crisis.

The purpose of this response is to minimize business impact and maintain critical operations. To remain resilient, companies should regularly test their disaster recovery plans to ensure they are fit for purpose and comply with accepted standards and customer expectations. According to Watters (2013), continuous testing of disaster recovery plans is essential to verify their effectiveness in mitigating technology risks and cybersecurity threats. Elkady *et al.* (2023) propose a decision support framework that emphasizes the prioritization of stakeholder interactions as a critical component of community resilience and trust-building during disaster recovery.

2.3 Supply Chain Resilience (SCRES)

SCRES refers to the ability of a supply chain to anticipate, respond to, adapt to, and recover quickly and efficiently from disruptions or problems (Rice and Caniato, 2003). Additionally, Pettit *et al.* (2013) defined SCRES in a similar manner, as a process that enables businesses to respond to crises and recover effectively. This concept is vital for organizations seeking to strengthen their resilience against adversity.

Recent research has expanded understanding of supply chain vulnerabilities and mitigation strategies. Martin (2024) examined supply chain uncertainties in terms of misalignment between private and public interests, responses to increased demand, transparency, and collaboration within complex systems. These analytical dimensions provide deeper insights into the root causes of supply chain vulnerabilities and inform the development of targeted mitigation measures, particularly relevant during global crises such as pandemics or geopolitical conflicts (Gruchmann *et al.,* 2024).

The following components of supply chain resilience were developed to assess SCRES strategies in the face of crises. These features are divided into four parts, addressed as follows:

(1) Flexibility – flexibility of operations and logistics in response to change and uncertainty. Flexibility is a cornerstone of SCRES, in that it enables a quick reset of processes and resources (Wieteska, 2020);
(2) Agility – the time when the supply chain is able to respond to changes in demand and supply, for the supply chain to easily respond quickly in times of crisis. Agility enables anticipation as well as responsiveness through anticipation and responsiveness before and after, and supports overall strengthening (Yawson and Yamoah, 2022);
(3) Robustness – the robustness of a classifier is its ability to maintain performance in the face of these events. Robustness is an important feature of the SCRES model (Gruchmann *et al.,* 2024);
(4) Recoverability – the capability to restore operations effectively following any interruption. This feature encompasses both immediate recovery processes and long-term sustainability when returning to normal business operations post-disruption (Gruchmann *et al.,* 2024).

From the literature review, it is evident that BCM can help both the manufacturing and service sector in minimizing the impacts of any crisis, while supporting supply chain recovery. The successful integration of business continuity management and supply chain recovery in manufacturing and service industries requires robust internal support for planning. This includes the development of Business Continuity Plans (BCP), Recovery Plan (RP), Crisis Management (CM), and Emergency Management (EM).

These insights from the literature form the basis for the following research hypothesis:

H_1: Business continuity management has a direct positive influence on supply chain recovery in both the manufacturing and service industries.

Although Business Continuity Management is widely recognized as a critical driver of supply chain resilience, the mechanisms through which BCM contributes to resilience are likely to vary across industries due to differences in crisis characteristics and operational structures. Manufacturing supply chains are primarily exposed to disruptions related to material shortages, production shutdowns, capacity constraints, and logistics interruptions. In contrast, service supply chains are more vulnerable to demand volatility, workforce availability, service continuity, and customer trust erosion during crisis situations. Therefore, analyzing the model across both manufacturing and service industries enables a more nuanced understanding of the differentiated mechanisms through which BCM strengthens supply chain resilience.

Table 1 Details of Construct and Indicator

Construct	Indicator
Business Continuity Management (BCM)	Business Continuity Plan (BCP) Recovery Plan (RP) Crisis Management (CM) Emergency Management (EM)
Supply Chain Resilience (SCRES)	Flexibility Agility Robustness Recoverability

Table 2 Source of Measurement Items Used in the Questionnaire

Variable	Measurement Item	Source
BCP	1) The organization has a concrete business continuity plan. 2) The organization implements its business continuity plan effectively. 3) Roles and responsibilities of staff are clearly divided to avoid redundancy. 4) Continuity policies are regularly communicated to staff.	Riglietti *et al.* (2021); Riglietti *et al.* (2022); Shashi *et al.* (2020); ISO (2019)
RP	5) The organization has a recovery plan in place. 6) Progress reports are consistently submitted to executives. 7) Resource recovery is tracked and evaluated effectively. 8) Staff are informed about the readiness and availability of resources. 9) Recovery plans are communicated to stakeholders and partners.	Riglietti *et al.* (2021); Riglietti, *et al.* (2022); Shashi *et al.* (2020); ISO (2019)
CM	10) The organization regularly assesses system risks. 11) The organization communicates and collaborates with stakeholders during crises. 12) Crisis management teams assess damage and impact comprehensively.	Riglietti *et al.* (2021); Riglietti, *et al.* (2022); Shashi *et al.* (2020); ISO (2019)
EM	13) Employees can substitute for each other during emergencies. 14) Emergencies or crises are promptly communicated to relevant staff. 15) Backup personnel are quickly deployed when needed.	Riglietti *et al.* (2021); Riglietti, *et al.* (2022); Shashi *et al.* (2020); ISO (2019)
Flexibility	16) The organization operates flexibly in procurement and scheduling. 17) The organization offers various products/services to meet customer needs. 18) Operational contracts allow flexibility in orders, payments, and delivery. 19) The organization has multi-skilled labor adaptable to different tasks. 20) Staff are trained to handle potential crises.	Rajesh (2021); Chowdhury and Quaddus (2017)
Agility	21) The organization can make quick decisions in response to changes. 22) Supply chain operations are rapidly managed aligning with organization's decisions. 23) The organization can scale operations up or down as needed. 24) The organization can adjust customer orders based on requests.	Altay *et al.* (2018); Scholten and Schilder (2015)
Robustness	25) The organization can continue operating as steadily as before the crisis. 26) The organization has sufficient time to respond to disruptions. 27) The organization can operate well during changing conditions. 28) The organization can continue operating under crisis even if some damage is sustained.	Singh *et al.* (2019); Ivanov and Dolgui (2020)
Recoverability	29) The organization easily restores the supply of materials and services. 30) The organization can return to normal operations efficiently in a short period of time. 31) The supply chain quickly recovers to its normal state. 32) Business disruptions are managed promptly.	Hosseini *et al.* (2019); Chowdhury and Quaddus (2017)

3. METHODOLOGY

3.1 Population and Sample

The population of quantitative study comprises 73,232 officially registered manufacturing establishments in Thailand, as well as 423,009 registered service business establishments in Thailand (Department of Business Development, 2022). The unit of analysis is an organization of the manufacturing sector and the service sector. Data were collected from operational personnel and executives within the industrial and service sectors who had direct experience with various crisis situations.

The sample size in this study was determined based on Hair *et al.* (2010), which recommended using 10-20 times the number of observed variables. For this research, there were eight observed variables. The researcher applied the upper bound of this recommendation, using a ratio of 20 times per observed variable. Therefore, the minimum required sample size for this study was at least 160 organizations for each sector. However, Comrey and Lee (1992) suggested that the criteria for a good sample size in factor analysis or structural equation modeling (SEM) are to collect a minimum of 300 responses. Thus, the sample size should include at least 320 organizations.

Table 3 Evaluating the Data-Model Fit

Fit Index	Criteria	Source
CMIN/df	<3	Hair *et al.* (2006)
GFI	>0.9	Hooper *et al.* (2008)
CFI	>0.9	Hair *et al.* (2006)
NFI	≥ 0.95 good, 0.90-0.95 acceptable	Bentler (1990)
TLI	≥ 0.9	Marsh *et al.* (2004)
RMSEA	0.03-0.08	Hair *et al.* (2006)

In total, 700 establishments were contacted by questionnaire between March and July 2024, with an equal allocation of 350 firms from each sector. Both groups were selected by a purposive sampling methodology to minimize possible data errors. The researcher initially contacted each business establishment by telephone to explain the research objectives and seek their participation. Upon receiving consent, questionnaires were distributed using both online and offline methods. For the online approach, a questionnaire link was emailed to participants, while for the offline approach, printed copies were either delivered in person or sent directly to the business address by mail. Ultimately, 450 questionnaires were returned. However, upon checking for completeness, 16 questionnaires were found to be incomplete and were therefore excluded from the analysis. Consequently, 434 fully completed questionnaires remained, meeting the required sample size criteria.

3.2 Measurement and Questionnaire Design

The questionnaire was based on a review of relevant literature. To ensure consistent interpretation of crisis-related questions, the questionnaire provided an explicit definition of the term "crisis" and specified clear criteria regarding its scope and severity on the first page of the questionnaire. The scope of the crisis was defined at both the organizational and supply chain levels, encompassing disruptions that affect internal operations as well as upstream and downstream partners. Crisis severity was characterized based on three conditions:

(1) The interruption of core production or service delivery activities;
(2) the inability to operate under normal procedures; and
(3) the requirement for managerial intervention, emergency response, or coordinated recovery efforts within the organization or across the supply chain.

Additionally, examples provided to respondents included pandemics, major supply disruptions, natural disasters, cyberattacks, and sudden market shutdowns.

The questionnaire comprised two main sections: Section 1 contained questions related to the general information of the establishments; Section 2 focused on issues concerning BCM and SCRES in crisis situations. This section included 32 items measured using a Likert rating scale ranging from the lowest to the highest, as follows: 1 = Strongly disagree and 5 = Strongly agree. The details of the constructs and indicators are shown in Table 1, while the specific questions are presented in Table 2.

For the validity and reliability measurement of the research instrument, both content validity and internal consistency were assessed, as follows:

(1) Content Validity: the Index of Item-Objective Congruence (IOC) was employed to assess the alignment between each questionnaire item with the research objectives. The instrument was reviewed by three experts, two specializing in supply chain management and one in the manufacturing industry. The IOC values assessed by the experts ranged from 0.67 to 1.00, which exceeds the commonly accepted threshold of 0.50 (Rovinelli, 1976), thereby indicating satisfactory content validity.
(2) Reliability: The questionnaire's reliability was pilot tested on 40 respondents and internal consistency was calculated using Cronbach's Alpha Coefficient. The result of the analysis was 0.981, which is higher than the commonly accepted threshold of 0.70 (Cronbach, 1951), indicating that the questionnaire demonstrated high reliability.

3.3 Data Analysis

Structural Equation Modeling (SEM) was used, allowing for simultaneous measurement of the measurement model and the structural model. Confirmatory factor analysis (CFA) was employed with the measurement model to validate the congruence between the model and the empirical data. In this study, BCM and SCRES are viewed for both the manufacturing and service industries in Thailand. The process of analysis is as follows:

(1) The appropriateness of the components was assessed using the sample data to determine their suitability for inclusion in the model. This was done by evaluating the following criterion:
   - Factor Loadings (FL) – the loading values between indicators and their respective components must exceed 0.50 which is the accepted threshold in this research (Kilic *et al.,* 2020);
   - Composite Reliability (CR) – composite reliability of each construct must exceed 0.70 to ensure internal consistency of the indicators (Hair *et al.,* 2006);
   - Average Variance Extracted (AVE) – the AVE value for each latent variable should be greater than 0.50, reflecting that the construct explains more than half of the variance of its indicators (Hair *et al.,* 2006); and
   - Cronbach's Alpha Coefficient – the alpha value should be greater than 0.70 to indicate acceptable internal consistency reliability (Cronbach, 1951).
(2) The structural model was analyzed to test the research hypotheses based on the research conceptual framework and empirical data, using the same goodness of fit criteria. SPSS software was used for general data analysis, and AMOS software was employed for analyzing the structural equation model. The consistency of the BCM and SCRES model for industries in Thailand was assessed using model fit evaluation criteria. The criteria for evaluating the data-model fit are presented in Table 3.

Table 4 Confirmatory Factor Analysis (CFA), Reliability and Validity of Construct Indicators

Construct	Item	Factor loading (>0.50)	CR (>0.70)	AVE (>0.50)	Cronbach's Alpha (>0.70)
Business Continuity Management (BCM)	BCP	0.835	0.743	0.920	0.884
	RP	0.914			
	CM	0.871			
	EM	0.826			
Supply Chain Resilience (SCRES)	Flexibility	0.755	0.861	0.608	0.916
	Agility	0.802			
	Robustness	0.786			
	Recoverability	0.774			

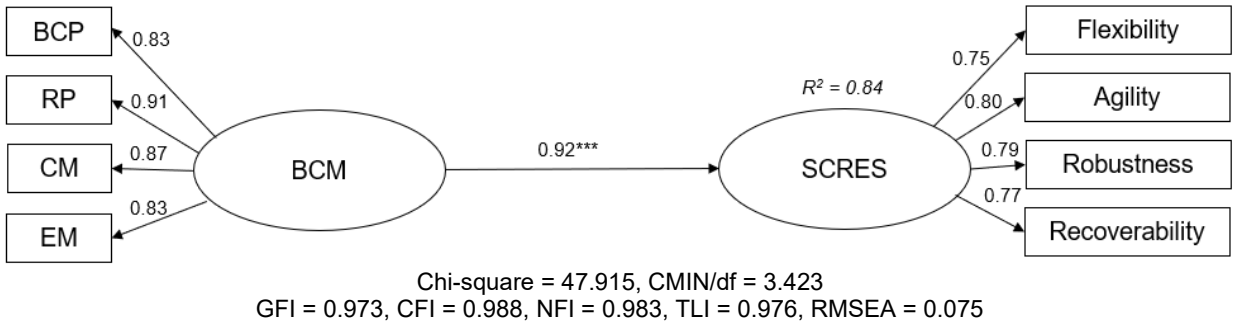

Figure 2 Structural Equation Model of the Relationship between BCM and SCRES in Thai Industry

3.4 Validate the Proposed Model

To further enhance the completeness of the proposed model, additional qualitative validation was conducted through in-depth interviews with key informants from both the manufacturing and service sectors. The study employed in-depth interviews to capture practical insights related to business continuity management and supply chain resilience practices.

Key informants were selected using a purposive sampling approach, supplemented by snowball sampling and criterion-based sampling. The selection criteria for key informants, following the methodological guidelines proposed by Patten *et al.* (2020), were as follows:

(1) individuals holding executive or senior managerial roles, or those directly involved in organizational management;
(2) a minimum of five years of managerial or organizational leadership experience;
(3) representation from organizations that have implemented business continuity management practices and experienced supply chain recovery in either the manufacturing or service industries; and
(4) voluntary consent to participate in the interview process for this study.

4. RESULTS

4.1 Respondents' Descriptive Analysis

In this study, a total of 450 responses were received, of which 434 responses (96.44%) were fully completed and considered usable for analysis. The sample group consisted of a nearly equal distribution of manufacturing and service business establishments, representing 54.6% and 45.4% of the total, respectively. The largest category of the surveyed establishments were small enterprises (with fewer than 50 employees), accounting for 38.5%, followed by medium-sized enterprises (51–200 employees) and large enterprises (more than 200 employees), representing 32.0% and 29.5%, respectively. Most of the establishments had been in operation for more than 15 years (29.5%) and were primarily sole proprietorships or family-run businesses (37.3%), followed by limited companies (32.7%).

4.2 Reliability and Validity Analysis

The result of the Confirmatory Factor Analysis (CFA) for BCM and SCRES in Thailand's industries showed that all the measured variables were above 0.50 in terms of factor loadings. Thus, the questionnaire had structural validity (Hair *et al.,* 2014). The results are presented in Table 4.

Table 4 presents the values of Factor Loadings, Composite Reliability (CR), Average Variance Extracted (AVE), and Cronbach's Alpha Coefficient. The results indicate that both main components, BCM and SCRES, as well as the eight indicators, met the established threshold criteria. This indicated that the measurement model was appropriate, statistically valid, and met the established evaluation criteria.

4.3 Structural Equation Model

The final analysis of the Structural Equation Model (SEM), conducted to examine the components of BCM and SCRES, revealed that the model was consistent with the empirical data. The observed variables significantly contributed to their respective latent constructions, with factor loadings ranging from 0.755 to 0.914, thus exceeding the accepted threshold of 0.50 (Kilic *et al.,* 2020).

4.4 Results of the Structural Equation Model

The analysis of the structural equation model (SEM) examining the relationship between BCM and SCRES in Thailand's industrial sectors revealed that the model fits the empirical data well. The fit indices were as follows: CMIN/df = 3.423; GFI = 0.973; CFI = 0.988; NFI = 0.983; TLI = 0.976 and RMSEA = 0.075. These values indicate that the measurement model demonstrates a satisfactory level of fit with the empirical data according to established criteria. Additionally, the model was well aligned and consistent with the empirical data, as illustrated in Figure 2

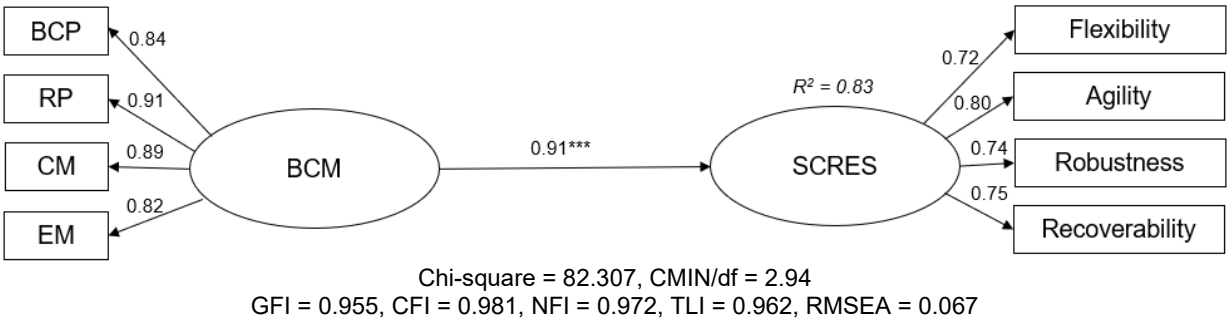

Figure 3 Structural Equation Model of the Relationship between BCM and SCRES in the Manufacturing Group

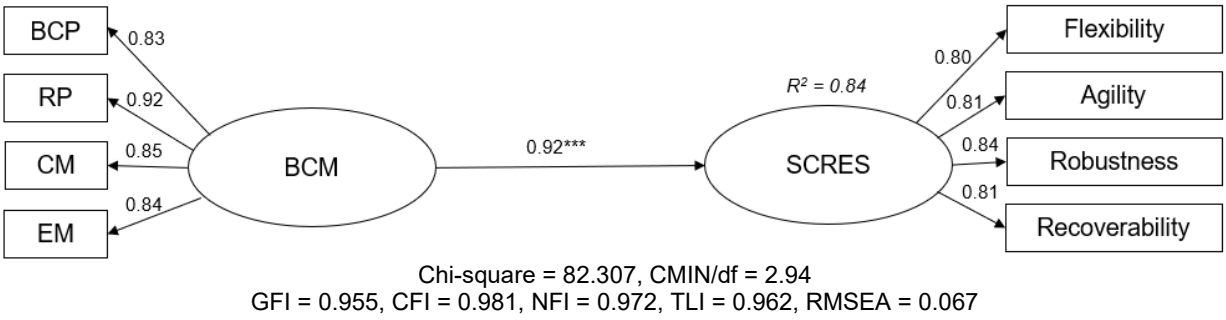

Figure 4 Structural Equation Model of the Relationship between BCM and SCRES in the Service Group

Figure 2 shows the results of the SEM analysis of the relationship between BCM and SCRES in Thailand's industrial sectors indicate that BCM had a statistically significant positive influence on SCRES at the 0.001 level. Moreover, the squared multiple correlations (R^2) obtained from the regression equation was 0.84, which implies that 84% of the variance in SCRES can be explained by BCM. The remaining 16% is attributable to other factors not included in this study.

The latent construct of BCM comprised four observed variables: RP, CM, BCP, and EM, in order of factor loading strength. The latent construct of SCRES also comprised four observed variables, with Agility demonstrating the highest factor loading, followed by Robustness, Recoverability, and Flexibility.

Figures 3 and 4 show SEM analysis results of the relationship between BCM and SCRES in Thailand's manufacturing and service industries, respectively. The results indicated that BCM had a statistically significant positive effect on SCRES at the 0.001 significance level in both industries. When considering the squared multiple correlations (R^2) derived from the regression equations in both sectors, the differences are minimal. The R^2 value for the manufacturing industry was 0.83, while for the service industry it was 0.84. This implies that 83% of the variance in supply chain recovery in the manufacturing sector and 84% in the service sector can be explained by business continuity management practices.

When examining the factor loadings of the observed variables under the BCM construct, slight differences were found between the manufacturing and service industries. RP and CM were the top two variables with the highest factor loadings in both sectors. Meanwhile, BCP ranked third in the manufacturing sector but fourth in the service sector. In contrast, EM had the lowest factor-loading in the manufacturing sector but ranked third in the service sector.

Table 5 The Details of Informants

Informant	Industry	Position
Informant 1	An automotive parts manufacturer reliant on imported steel coils	Quality assurance manager
Informant 2	A steel processing and distribution company serving the automotive industry	Senior manager
Informant 3	Truck transportation and hotel operations	Business owner

The factor-loadings of the observed variables under SCRES construct differed between the manufacturing and service sectors. For the manufacturing sector, the observed variable with the highest loading was Agility, whereas for the service sector, it was Robustness. The subsequent factor-loading in the manufacturing sector, in descending order, were Recoverability, Robustness, and Flexibility. In the service sector, the next highest factor loadings were Agility, Recoverability, and Flexibility, respectively.

4.5 Model Validation

Following the quantitative analysis, the proposed model was further validated using evidence from real-world industrial contexts in both the manufacturing and service sectors. This validation was conducted through in-depth interviews with organizations that had experienced major supply chain disruptions and successfully recovered to normal operational conditions after crisis events. The details of informants are shown in Table 5.

The in-depth interviews included eight questions aligned with the study variables, covering the four components of Business Continuity Management (BCM): Crisis Management (CM), Emergency Management (EM), Recovery Plan (RP), and Business Continuity Planning (BCP), as well as the four dimensions of Supply Chain Resilience (SCRES): flexibility, agility, robustness, and

Table 6 Summary of Interview Findings by Factor and Industry Sector

Factor	Manufacturing Sector (Informant 1 & Informant 2)	Service Sector (Informant 3)
CM	• Formal crisis governance and assigned crisis teams • Scenario simulation • Continuous risk assessment • FMEA integrated into management of change • Real-time shipment/container tracking	• Financial risk assessment and liquidity planning • Rapid managerial decision-making • Stakeholder involvement and coordination • Strategic business model restructuring
EM	• Clearly defined emergency roles and responsibilities • Internal risk assessment (skills, machines, materials) • External risk assessment (regulatory, ISO, cyber risks) • Management review meetings and audit systems • Corrective actions and documentation as organizational knowledge	• Workforce protection and readiness • Strategic operational and financial decisions • Continuity of service delivery
RP	• Root Cause Analysis • Corrective and preventive actions • System- and process-level recovery	• Business recovery procedures • Situation monitoring and progress reporting • Resource impact assessment • Budget planning and cost control • Digital transformation initiatives
BCP	• End-to-end continuity planning (procurement–production–logistics) • Reduced reliance on single suppliers • Domestic sourcing strategies • Departmental BCPs aligned with corporate vision • Long-term roadmap (e.g. over the next five years)	• Systematic risk assessment • Role clarity and coordination • Structured meetings • Centralized communication (“one voice, one message”)
Flexibility	• Adjustment of sourcing strategies, production systems, and logistics operations • Seeking new customers • Introduction of new product models and process adaptations • Alternative sourcing (domestic substitution) • Transport mode switching (sea → air) • Order-based production	• Workforce scaling and outsourcing • Flexible task allocation • Multi-skilling of employees • Adaptable SOPs
Agility	• Rapid problem detection and response • On-site QA intervention and immediate rework • Fast sourcing and logistics decisions • Strong vertical and horizontal communication	• Rapid workforce redeployment • Role switching and flexible scheduling • Reduced approval layers to facilitate fast decision-making
Robustness	• Maintenance of safety stock for critical materials • Investment in high-reliability machinery, supported by preventive maintenance and spare parts • Reliable suppliers and long-term contracts • Kaizen principles for continuous improvement • Human resource contingency planning • Internal, external, and cross-company audits • Technology investment (e.g. RFID, automated inspection processes, and AI-enabled monitoring systems)	• Core service prioritization • Effective resource allocation • Clearly defined procedures for service resumption • Backup databases and IT systems to support workforce management stability and transparent customer communication
Recoverability	• Clear recovery plans • Prioritizing production orders and managing inventory following disruptions • Preparation of critical machinery, spare parts, and emergency maintenance teams • Use of real-time information systems and production data • Rapid and systematic restoration of operations through effective management practices • Implementation of modern software systems across the operational chain	• Innovation and differentiation • Organizational learning and mindset change • Continuous monitoring and evaluation of recovery measures • Performance tracking and feedback mechanisms • Use of digital technologies and AI-enabled transformation

recoverability. The interview findings provide practical evidence that supports the quantitative results and demonstrate how these variables are operationalized in real organizational context. The detailed results of the interviews are provided in the Appendix. The summary of the interviews is as follows:

For crisis management, manufacturing firms emphasized formal crisis governance, dedicated crisis teams, scenario simulations, continuous risk assessment, and the use of analytical tools such as FMEA and real-time tracking systems to improve preparedness and decision-making. In contrast, the service firm placed greater emphasis on financial risk assessment, liquidity planning, stakeholder coordination, and strategic adaptation of the business model. Regarding emergency management, manufacturing firms relied on structured systems with clearly defined roles, multi-level risk assessments, management review mechanisms, and the documentation of corrective actions as organizational knowledge. In the service context, emergency management was more workforce-centered, with Human Resource Management (HRM) playing a major role in coordinating operational and financial responses, protecting employees, and maintaining service continuity. For recovery planning, manufacturing firms focused on systematic root cause analysis, corrective and preventive actions, and rapid restoration at both process and system levels, whereas the service firm adopted a more adaptive approach involving business recovery procedures, continuous monitoring, resource assessment, budget control, and digital transformation initiatives. In relation to business continuity planning, manufacturing firms emphasized end-to-end continuity planning across procurement, production, and logistics, supported by supplier diversification, domestic sourcing, and long-term planning. In contrast, the service firm highlighted risk assessment, role clarity, structured meetings, and centralized communication under the "one voice, one message" principle.

The interview findings also confirm the manifestation of all four SCRES dimensions in practice. Flexibility in manufacturing was reflected in adjustments to sourcing, logistics, production systems, and product design, while service flexibility was primarily driven by workforce scaling, outsourcing, multi-skilling, and adaptable Standard Operating Procedures (SOPs). Agility in manufacturing was demonstrated through rapid problem detection, on-site QA intervention, fast sourcing decisions, and strong coordination, whereas in the service sector it was reflected in rapid workforce redeployment, flexible scheduling, and faster decision-making through fewer approval layers. Robustness in manufacturing was supported by safety stock, reliable suppliers, preventive maintenance, high-reliability machinery, Kaizen-based continuous improvement, and audit systems, while service robustness depended more on core service prioritization, effective resource allocation, IT backup systems, and transparent customer communication. Finally, recoverability in manufacturing was grounded in formal recovery plans, emergency maintenance readiness, production data, and software-supported restoration processes, whereas the service firm viewed recovery more broadly as a process of innovation, organizational learning, mindset change, continuous evaluation, and digital transformation. Overall, the interview evidence confirms that BCM serves as the structural foundation of resilience, while sector-specific operational characteristics shape how resilience capabilities are developed and applied in practice.

The Summary of interview findings is shown in Table 6. The results highlight sector-specific mechanisms through which BCM components and SCRES dimensions are operationalized in practice.

5. DISCUSSION

The first objective of this study was to examine the relationship between Business Continuity Management (BCM) and Supply Chain Resilience (SCRES) in manufacturing and service industries. The Structural Equation Model (SEM) results confirm that BCM has a strong and direct positive impact on SCRES across both sectors, with path coefficients of 0.92 for the overall model, 0.91 for the manufacturing sector, and 0.92 for the service sector. These findings provide robust empirical support for the hypothesis and are consistent with prior studies emphasizing the role of BCM in strengthening organizational preparedness, responsiveness, and recovery during crisis situations (Charoenthammachoke *et al.,* 2020; Riglietti, 2022; Vishkaei and Di Giovanni, 2024).

BCM improves SCRES by integrating the four key resilience dimensions: flexibility, agility, robustness, and recoverability, into organizational processes. Through structured risk assessment, business impact analysis, and recovery-oriented planning, BCM enables organizations to respond effectively to unexpected disruptions and allocate resources efficiently under crisis conditions (ISO, 2019; Suresh *et al.,* 2020; Ambarwati *et al.,* 2024). Importantly, the consistency between the SEM findings and the qualitative model validation confirms that the proposed BCM–SCRES model aligns well with actual organizational practices in the Thai industrial context.

With respect to the individual components of BCM, RP emerged as the most influential driver of SCRES in both manufacturing and service sectors, exhibiting the highest factor loadings across all models. The RP ensures a rapid return to operational normalcy through clear resource allocation, restoration protocols, and ongoing evaluation (Turulja and Bajgorić, 2022; Rifai and Faqih, 2017). This finding reflects the critical importance of recovery mechanisms in the Thai context, where organizations must cope with recurring disruptions such as pandemics, logistics delays, supply shortages, and geopolitical uncertainty. In practice, Thai manufacturing firms emphasized structured recovery mechanisms such as root cause analysis, corrective and preventive actions, system-level recovery, and production recovery plans supported by real-time operational data. These practices enable rapid restoration of production capacity and minimize prolonged disruption. Similarly, service organizations highlighted business recovery procedures, situation monitoring, resource impact assessment, budget control, and digital transformation initiatives as central to restoring service continuity.

CM ranked as the second most influential BCM component in both sectors, highlighting the importance of timely decision-making, coordinated communication, and leadership during crisis events. Research by Durugbo and Al-Balushi (2023), Mwaiwa and Odiyo (2015), and Watters (2013) highlights CM's vital role in resource planning, communication, and rapid decision-making, which should be aligned with an organization's broader BCM strategy.

In the Thai industrial context, CM plays a vital role in managing uncertainty, aligning internal and external stakeholders, and enabling rapid organizational responses, particularly during large-scale disruptions such as COVID-19 and global logistics crises. Manufacturing firms rely on formal crisis governance structures, scenario simulations, continuous risk monitoring, and real-time logistics tracking to support timely decision-making during disruptions. The integration of tools such as Failure Mode and Effects Analysis (FMEA) into management-of-change processes enhances situational awareness and response speed. In service industries, CM is strongly associated with rapid managerial decision-making, stakeholder coordination, financial risk assessment, and business model restructuring.

BCP demonstrated moderate influence on SCRES, ranking third in the manufacturing sector and fourth in the service sector. BCP focuses on identifying critical business functions and developing strategies to ensure their continuity during disruptions. According to the interviews, Thai manufacturing firms described BCP as an end-to-end continuity framework covering procurement, production, and logistics, with a strong focus on reducing reliance on single suppliers, developing domestic sourcing strategies, and aligning departmental BCPs with long-term corporate vision. Service organizations also acknowledged the importance of systematic risk assessment, role clarity, structured coordination, and centralized communication.

EM exhibited the lowest impact in manufacturing but a higher relative importance in the service sector. This difference reflects the sector-specific characteristics of Thai service industries, where immediate on-site response, workforce coordination, and customer safety are critical due to direct service interaction. Service-sector respondents highlighted EM as more critical due to the need for immediate workforce coordination, employee protection, and continuity of customer-facing operations. Industries such as transportation, hospitality, aviation, and IT services emphasized rapid emergency response and flexible human resource deployment to maintain service continuity and protect organizational reputation. This explains the higher relative importance of EM in the service-sector model. On the other hand, the manufacturing sector indicated that EM was primarily associated with clearly defined emergency roles, internal and external risk assessments, audit systems, and documentation for organizational learning. While these practices contribute to preparedness

The results of squared multiple correlations (R^2) indicate that Business Continuity Management explains a substantial proportion of supply chain resilience, with values of 0.84 for the overall model, 0.83 for the manufacturing sector, and 0.84 for the service sector. While these results confirm the strong explanatory power of BCM, the remaining 16–17% of unexplained variance suggests that supply chain resilience is also influenced by additional organizational and contextual factors beyond formal BCM practices. Evidence from the qualitative interviews indicates that this residual variance can be attributed to organizational culture, leadership mindset, digital capability, human capital adaptability, inter-organizational relationships, and learning orientation, which operate as complementary enablers of resilience but are not explicitly captured as core BCM constructs

Furthermore, the qualitative validation confirms that all four dimensions of SCRES: agility, flexibility, robustness, and recoverability, are clearly manifested in Thai organizational practices. Manufacturing firms tend to prioritize agility and recoverability, focusing on rapid adjustment of production systems and structured post-crisis recovery. In contrast, service organizations emphasize robustness and agility, reflecting the need to maintain stable service delivery while responding quickly to fluctuating demand and emergency conditions. These sector-specific resilience priorities reinforce the argument that BCM functions not merely as a risk management tool, but as a strategic mechanism that integrates response, recovery, and adaptation capabilities under highly uncertain crisis environments.

Overall, the findings confirm that the proposed BCM–SCRES model is both empirically valid and contextually relevant for explaining organizational behavior in Thailand's manufacturing and service industries.

6. MANAGERIAL AND BUSINESS IMPLICATIONS

This study provides several important managerial and business implications for strengthening SCRES through BCM in Thailand's manufacturing and service industries.

Managers should prioritize recovery-oriented BCM rather than treating BCM solely as a compliance or risk-control tool. The findings clearly indicate that the RP is the most influential BCM component across both sectors. Managers should therefore focus on developing clear recovery procedures, resource prioritization mechanisms, and post-crisis evaluation processes supported by real-time data and digital tools. In practice, organizations that invest in structured recovery planning, such as production recovery plans, service restoration protocols, and continuous monitoring systems, are better positioned to restore operations quickly and minimize long-term disruption impacts.

Moreover, BCM implementation should be sector-sensitive and aligned with operational characteristics. Manufacturing firms should emphasize BCM practices that support agility and recoverability, such as alternative sourcing strategies, flexible production planning, and system-level recovery mechanisms. In contrast, service organizations should place greater emphasis on crisis management and emergency management capabilities, including workforce coordination, customer communication, and continuity of service delivery.

7. FUTURE RESEARCH

Future research should extend the analysis to specific industries or international contexts in order to compare how BCM is implemented across different environments. In addition, the effectiveness of BCM is likely to be influenced not only by formal continuity practices but also by broader contextual factors, such as cultural, organizational, and regulatory conditions, which should be incorporated into future research for a more comprehensive understanding of resilience.

8. CONCLUSION

The present study aimed to (1) examine the relationship between Business Continuity Management (BCM) and Supply Chain Resilience (SCRES) in Thailand's manufacturing and service industries, (2) provide strategic BCM guidelines to strengthen SCRES in times of crisis, and (3) validate the proposed model with real-world business operations. The data were collected by questionnaire from the responses of 434 business organizations. The empirical findings confirm that BCM had a positive influence on SCRES. The analysis revealed that all four components of BCM: Business Continuity Plan (BCP), Recovery Plan (RP), Crisis Management (CM), and Emergency Management (EM), contribute to SCRES, with different degrees of influence depending on the sector. RP and CM are the most critical factors for both sectors. Meanwhile, BCP was third ranked in the manufacturing sector but fourth ranked in the service sector. Conversely, EM ranked third in the service sector but last in the manufacturing sector. Moreover, the study revealed clear differences in the prioritization of SCRES components between the two sectors. While the manufacturing industry emphasized agility, the service industry placed greater emphasis on robustness and recoverability. These structural differences underscore the need to develop specific BCM strategies that align with the specific characteristics of supply chains in each industry.

To further strengthen the validity of the findings, the quantitative results were supported by in-depth interviews with key informants from both manufacturing and service sectors. The interview evidence provides practical confirmation of how BCM is applied in real organizational settings and how firms respond to and recover from major supply chain disruptions. The interview results are highly consistent with quantitative analysis, underscoring the critical importance of structured recovery planning, effective crisis management, and sector-specific implementation of BCM practices. In addition, the interviews highlight complementary resilience enablers, such as digital capabilities, leadership commitment, workforce adaptability, organizational learning, and collaboration with supply chain partners, that reinforce supply chain resilience beyond formal BCM structures.

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DATA AVAILABILITY STATEMENTS

The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to appropriate privacy and confidentiality considerations.

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Baweena Ruamchart is an Assistant Professor in the Department of Logistics Management, Faculty of Management Sciences, Kasetsart University, Si Racha, Thailand. She holds a Master's degree in Logistics and Supply Chain Management from the University of Hull, United Kingdom, and a Ph.D. in Logistics and Supply Chain Management from Chulalongkorn University, Thailand. Her research interests include supply chain resilience, crisis management, business continuity management, and sustainable supply chain management.

Tanutpats Dhiratanuttdilok is an Assistant Professor at the Department of Logistics, Kasetsart University, Si Racha, Thailand. He received his Ph.D. in Management from the Faculty of Management Science, Silpakorn University, Thailand, and holds a Master of Science in Logistics Management from Chulalongkorn University. His research focuses on logistics and supply chain management, with particular interests in supply chain strategy, sustainability, and marketing logistics, as well as SMEs and consumer behavior in the digital economy. His work applies both quantitative and qualitative methods to support theoretical understanding and practical application.

Kusuma Piriyapun holds a Bachelor's degree in Business Administration (International Business) from Kasetsart University, Thailand, and a Master of Science in Transport and Logistics Management. Her research interests include operations management, transport planning, and sustainable supply chain management. She is currently a faculty member in the Business Administration Program (Logistics Management), Faculty of Management Science, Kasetsart University, Si Racha, Thailand.

Appendix. Results of in-depth interviews from 3 informants

Question 1: During a crisis, how does your organization manage the crisis?
Informant 1:
The organization established a crisis management team or assigned specific personnel with direct responsibility to ensure that operations and decision-making during crisis situations were conducted effectively and in a timely manner. Additionally, the organization implemented preparedness initiatives, including simulation exercises, such as cyberattack scenario simulations, to enhance readiness and improve decision-making capabilities under crisis conditions.

Informant 2:
The organization conducts systematic risk assessments across its operational systems and maintains close communication with internal departments to manage and resolve crisis situations. For example, in 2023, disruptions occurred when shipping lines were required to reroute vessels to avoid the Red Sea and detour around the African continent. This situation significantly increased transportation costs and lead times, causing interruptions to both the company's outbound deliveries and inbound receipt of components from overseas suppliers. After evaluating the situation as an unavoidable external disruption, the company implemented a policy to assign a dedicated task force to closely monitor developments every three days. In addition, top management approved a new initiative to implement a real-time container and shipping line tracking system, enabling the organization to identify shipment locations and improve systematic planning and decision-making. Notably, even after the shipping disruption was resolved, this initiative continued to enhance operational speed and efficiency compared with previous practices.
Furthermore, the organization performs continuous risk assessments across all functional units, requiring each department to evaluate risks in terms of severity, likelihood, and potential impact, along with appropriate risk mitigation measures and contingency plans. These assessments cover both operational and technical risks, such as machine capacity constraints and equipment breakdowns. In addition, all organizational changes are systematically evaluated through Failure Mode and Effects Analysis (FMEA) as part of the company's management of change process, thereby strengthening overall risk management effectiveness.

Informant 3:
Effective organizational crisis management requires senior management to place strong emphasis on financial risk assessment, as well as the systematic planning and management of organizational liquidity. These efforts should be accompanied by regular meetings and active involvement of key stakeholders, effective internal communication, and close attention to supply chain partners in order to mitigate potential impacts across the entire supply chain. In addition, strategic decisions regarding organizational restructuring and business model adjustment may be necessary to enhance the organization's ability to respond appropriately to crisis conditions.

Question 2: During a crisis, what emergency plans do your organization have in place?
Informant 1:
A well-structured emergency response plan with clearly defined roles and responsibilities is considered a critical factor for successful organizational operations. Senior management is responsible for analyzing and assessing risks affecting the organization and its stakeholders, as well as determining appropriate risk management approaches to maintain risks at acceptable levels. Department managers or section heads are tasked with evaluating risks that may affect organizational objectives and goals, and with implementing control measures to minimize potential impacts.
Representatives or assistants responsible for the quality management system are assigned to monitor, evaluate, and prepare summary reports for presentation at management review meetings. This process encompasses the control, mitigation, or elimination of risks at all organizational levels, including risks associated with operational activities and working environments. In addition, the organization conducts weekly meetings to review short-term objectives, during which policies, strategies, and crisis-related decisions are formulated to ensure effective business operations.

Informant 2:
During crisis situations, the organization conducts comprehensive internal risk assessments, covering aspects such as workforce skills, process and machine capability, and material inventory levels, as well as external risk assessments involving regulatory bodies (e.g., legal requirements), quality assurance and certification agencies (e.g., ISO), business partners, and cyberattacks. In response, the organization establishes emergency response plans to prevent system breakdowns, reflecting a systematic management approach that spans from preparedness and response to continuous review and improvement.
When deficiencies are identified, corrective actions are implemented through process revisions in accordance with continuous improvement principles. The results of risk assessments are reported to senior management and formally reviewed during management review meetings to support strategic oversight. Following approval, these outcomes are documented and retained as organizational knowledge for future reference.

Informant 3:
In emergency situations arising from crisis events, the Human Resource Management (HRM) function works closely with top management to systematically plan, respond, and make strategic operational and financial decisions. These coordinated efforts

aim to ensure the continuity of organizational operations, minimize adverse impacts on personnel, and enhance employee preparedness to respond effectively to emergency situations.

Question 3: During a crisis, how does your organization implement crisis recovery plans?
Informant 1:
The organization has established a recovery plan as a systematic guideline for identifying, analyzing, and eliminating the root causes of problems that have caused or may potentially cause adverse impacts on the quality management system and overall organizational operations. The plan covers both internal and external processes and emphasizes effective responses to incidents that have already occurred, as well as the rapid and efficient restoration of systems, processes, and operational performance to normal conditions.

Source 2:
Under the recovery plan, the organization systematically conducts root cause analysis to identify the underlying causes of problems. Relevant data are collected and analyzed to determine appropriate corrective actions for restoring operations, along with preventive measures to avoid recurrence at both the system and process levels. These actions aim to enhance operational efficiency and effectiveness while supporting the continuous improvement of the organization's management systems and operational processes, thereby ensuring long-term stability, sustainability, and compliance with applicable requirements.

Informant 3:
The organization developed a systematic crisis recovery plan that clearly specifies operational procedures, including the formulation of business recovery strategies to address damages, close monitoring of evolving situations, regular progress reporting, and continuous assessment of affected resources. These efforts are complemented by a strong emphasis on budget planning and cost control, particularly through the reduction of non-essential expenditures, as well as the continuous adjustment of operational plans to align with rapidly changing conditions.
In addition, the organization implemented digital transformation initiatives across both hotel and truck transport service in a comprehensive and integrated manner to enhance operational efficiency. Continuous monitoring and evaluation processes were also established within the organization, supported by strategic approaches aimed at enabling the organization to overcome crisis situations and achieve sustainable growth in the long term.

Question 4: During a crisis, how does your organization implement Business Continuity plan?
Informant 1:
Based on experiences related to the semiconductor shortage, which forced the automotive industry to reduce or suspend production capacity, delay deliveries, and cancel certain production orders, organizations faced significant production disruptions along with increased logistics and inventory holding costs. In response, the company developed a comprehensive Business Continuity Management plan covering procurement, production, transportation, and cost management. The plan emphasizes systematic raw material planning, reducing reliance on single-source suppliers, and promoting domestic sourcing to enhance preparedness for emergency situations.

Informant 2:
The organization makes a monthly production planning in coordination with senior management, with continuous monitoring of production performance. Each department is required to develop a Business Continuity Plan (BCP) that is aligned with the organization's overarching vision. Clear roles and responsibilities are defined, particularly with respect to information flow across departments and material flow throughout the supply chain. Furthermore, the organization has established a long-term planning horizon, setting clear objectives toward 2030 (over the next five years), outlining how information and material flow processes will be improved to achieve greater speed, integration, and operational efficiency.

Informant 3:
Business continuity planning is therefore essential, requiring organizations to conduct systematic risk assessments, clearly define roles and responsibilities among personnel, and communicate operational plans through structured meetings. Emphasis is placed on centralized and timely communication based on the "one voice, one message" principle to reduce confusion and prevent the dissemination of inaccurate information during crisis situations.

Question 5: How does your organization demonstrate operational flexibility in terms of adapting or adjusting work plans rapidly during a crisis?
Informant 1:
During crisis situations, such as the disruption caused by the blockage of the Suez Canal, material shortages occurred when steel coils could not be delivered on time. In response, the organization arranged urgent imports of steel coils via air transportation or sourced alternative materials from domestic suppliers. In addition, the company sought new customers and introduced new product models for pilot production, while simultaneously adjusting component designs and production processes to enable the use of substitute materials. These adaptive measures allowed the organization to continue meeting customer requirements under rapidly changing conditions.

Informant 2:
The organization adjusted its production strategy from high-volume manufacturing to a more flexible, order-based production approach, and temporarily shifted transportation modes from maritime shipping to air freight during urgent situations. These measures enabled the company to maintain continuous product delivery and minimize disruptions to customers' production lines, thereby reducing the overall impact of the crisis on downstream supply chain operations.

Informant 3:
Hotel businesses require continuous structural and operational adaptability to cope with demand uncertainty, crisis conditions, and human resource constraints. Flexibility in service supply chains is reflected through workforce planning that allows staffing levels to be scaled up or down according to situational demands, the appropriate use of outsourcing to substitute or enhance core operational capabilities, and the clear yet flexible allocation and redistribution of work responsibilities across organizational levels.
These practices rely heavily on effective communication systems, combined with continuous skill development through online training programs, enabling employees to perform multiple roles (multi-skilling). Furthermore, the presence of clear yet adaptable Standard Operating Procedures (SOPs) serves as a critical mechanism that allows service organizations to maintain continuity of service delivery and achieve rapid recovery under dynamically changing conditions.

Question 6: How does your organization respond quickly to changes, particularly in terms of its ability to detect problems early and take prompt action to prevent disruptions to production or service delivery?
Informant 1:
The organization demonstrated the ability to respond rapidly to operational problems and material supply constraints. For example, when customers encountered product quality issues, the company promptly deployed quality assurance (QA) teams to conduct root cause analysis and perform on-site rework at the customer's facilities. This approach reduced both costs and lead time associated with returning products for correction at the company's plant, minimized disruptions to the customer's production lines, and strengthened customer satisfaction and trust by demonstrating a strong commitment to quality and responsiveness.
In addition, when critical raw materials such as steel could not be delivered on time due to constraints in international maritime transportation, the organization temporarily adjusted its sourcing strategy by switching to domestic suppliers. This proactive approach helped prevent raw material shortages and avoided interruptions to customers' production lines.

Informant 2:
The organization has established a long-term development plan toward 2030, with a strategic focus on becoming more agile, innovation-driven, and committed to continuous improvement. This vision is intended to enhance the organization's ability to respond effectively to unexpected events. To achieve this goal, each organizational unit is required to develop action plans aligned with a shared strategic direction, supporting the envisioned organizational profile. Continuous information sharing and communication are emphasized across both vertical (top–down and bottom–up) and horizontal channels to ensure effective coordination and integration throughout the organization.

Informant 3:
Hotel businesses must be able to rapidly adjust workforce levels and service delivery models in response to sudden fluctuations in occupancy rates. Such adjustments may include scaling service operations up or down, modifying work schedules, or reallocating employee roles. In this context, the development of multi-skilled employees capable of quickly switching roles and substituting for one another is critically important, particularly during periods of resource constraints. Moreover, streamlined internal communication systems that reduce approval layers and accelerate decision-making processes enable organizations to respond promptly and effectively to unexpected events.

Question 7: How does your organization maintain stable operations and continue business activities during crisis situations?
Informant 1:
In response to challenges in automotive parts manufacturing, the company adopted advanced technologies such as RFID systems, automated goods-receipt inspection and on-site tag printing, and AI-enabled cameras to enhance safety management. Work processes were continuously improved to increase accuracy, convenience, and speed through the implementation of Kaizen principles, whereby employees are encouraged to propose improvement initiatives on a monthly basis. These proposals are presented to senior management, with incentive bonuses provided as rewards. In addition, the organization regularly conducts training programs to enhance employees' operational skills and competencies.

The company also maintains appropriate levels of safety stock for critical raw materials and components, particularly in the automotive and electronics industries, to mitigate risks associated with delays in international sourcing. Furthermore, several manufacturing facilities have invested in high-reliability machinery, supported by preventive maintenance systems and essential spare parts, to reduce the likelihood of production line disruptions. These efforts are complemented by the selection of reliable key suppliers, the establishment of long-term supplier relationships, and clearly defined procurement contracts, all of which contribute to reducing uncertainty in material quality and supply volume.

Informant 2:
The organization was able to maintain operational continuity at a level close to pre–COVID-19 conditions through the implementation of human resource contingency plans designed to address labor shortages. These measures included the use of subcontracted labor as a substitute workforce, together with daily monitoring and assessment of operational conditions. As a result, the impact on production was kept at a limited level, enabling the business to recover rapidly.
At the same time, the organization operates a robust audit and assessment system, encompassing external audits, internal audits, and cross-company audits within affiliated firms. These mechanisms continuously reinforce the stability, reliability, and governance of supply chain processes, thereby strengthening overall supply chain resilience.

Informant 3:
Service organizations establish systematic prioritization of core services, resource allocation, and structured procedures for service resumption. In addition, they utilize information technology systems and backup databases to support rapid operational recovery, alongside effective workforce management and transparent communication with customers to mitigate negative impacts on customer confidence. As operations begin to recover, organizations incorporate lessons learned from crisis events to improve service processes and strengthen preparedness plans for future disruptions.

Question 8: How does your organization recover its operations, particularly in terms of its ability to return to normal production or service levels as quickly as possible after disruption events?
Informant 1:
The organization has established a clear Production Recovery Plan and Business Continuity Plan (BCP) that specify procedures for restoring production lines, prioritizing production orders, and managing inventory following disruption events. In addition, the company prepares critical machinery, spare parts, and emergency maintenance teams to ensure that production lines can be restarted within the shortest possible time. These efforts are further supported by the application of real-time information systems and production data, which enable management to assess impacts, plan recovery actions, and adjust production schedules more effectively.

Informant 2:
The organization places strong emphasis on restoring operational processes to normal conditions rapidly and systematically, supported by effective management practices and a stable long-term customer base as key enabling mechanisms. The company is committed to maintaining high-quality standards as a steel processing and distribution center for the automotive industry, supported by precise production processes, advanced warehousing systems, and high-accuracy machinery. In addition, modern software systems are implemented throughout the operational chain—from inbound logistics and production to storage and outbound distribution via both truck and maritime transportation—under the principle of error prevention, ensuring timely, accurate delivery and high customer satisfaction.
In response to increasing competition in the electric vehicle (EV) automotive industry, the company conducts systematic impact assessments and has developed a long-term business plan in collaboration with supply chain partners, incorporating changing trends in internal combustion engine usage. This strategic approach enables the organization to more effectively plan internal resources, such as aligning workforce levels with value creation and investment costs. Consequently, the company has shifted its strategic focus from a traditional sales-volume-driven production model toward a model emphasizing investment efficiency and long-term business value.

Informant 3:
Organizational recoverability after a crisis is not limited to restoring operations to their previous state, but rather involves learning, adaptation, and long-term transformation. Several respondents emphasized that recovery should be viewed as an opportunity to create innovation and differentiation, enabling organizations to strengthen their competitiveness and achieve sustainable growth after crisis events.
Developing appropriate mindsets among employees is also important, noting that operational-level staff often resist change, whereas middle- and senior-level employees must cultivate flexibility and an understanding that business conditions can change rapidly and unexpectedly. Building awareness and shared understanding across organizational levels was considered essential for effective recovery.
In addition, respondents stressed that organizational adaptation must be continuously monitored and evaluated to assess whether recovery measures are effective. Systematic follow-up, performance tracking, and feedback mechanisms were viewed as critical components that allow organizations to learn from crisis experiences and refine recovery strategies.
Finally, technology, particularly digital tools and artificial intelligence is significant in supporting post-crisis recovery. Such technologies were perceived as key enablers for improving decision-making, enhancing operational efficiency, and facilitating business transformation, thereby strengthening the organization's capacity to recover and remain resilient in the long term.