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Assessing data-driven sustainable supply chain management indicators for the textile industry under industrial disruption and ambidexterity

Abstract

This study contributes to developing the existing knowledge regarding data-driven sustainable supply chain management (SSCM) indicators under industrial disruption and ambidexterity. SSCM is a type of information flow management that facilitates cooperation and collaboration among supply chain players and stakeholders while considering economic, social, and environmental perspectives. Previous studies have failed to (1) generate these indicators from databases and confirm the validity of the effective indicators; (2) build a hierarchical structure with interrelationships under industrial disruption and ambidexterity; and (3) identify the indicators necessary for effective textile performance. The proposed hybrid method generates indicators from a database and based on the existing literature. This study proposes using the fuzzy Delphi method to validate these indicators in the textile industry and applies the best and worst methods to examine the most effective and ineffective indicators. Valid aspects and criteria are used to construct a hierarchical structure under conditions of industrial disruption and ambidexterity. The results show that the most important aspects are financial vulnerability, supply chain uncertainty, risk assessment, and resilience; these aspects are drivers that are guaranteed to ensure the effectiveness of SSCM under industrial disruption and ambidexterity. Financial crisis response, business continuity, supply chain integration, bullwhip effect, facility location, and supplier selection are highlighted as vital practical strategies.

Keywords: sustainable supply chain management; disruption and ambidexterity; fuzzy Delphi method; best and worst method

industry under industrial disruption and ambidexterity

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1. Introduction

The importance of sustainable supply chain management (SSCM) has increased in recent decades due to global population growth, resource restrictions, consumption activities, and increasing levels of waste and pollution (Rebs et al., 2019, Bui et al., 2021; Lin et al., 2019). The textile industry is one of the largest global industries, and sustainable management concepts have been implemented in the industry's supply chain (SC) networks. The textile industry in Vietnam has achieved substantial growth, with an average growth rate of approximately 30 percent per year, and it accounts for 20 percent of the country's export revenue (Wang et al., 2020). The textile industry plays an important role in the national economy, as it not only fulfils increasing and diverse consumption demands but also generates employment, considerably promotes economic development, and contributes to the national budget (Ho and Watanabe, 2020; Poursoltan et al., 2021). The textile industry has faced pressure due to its roles in both resource exhaustion and ecological contamination, and immense efforts are being made to identify the necessary indicators to solve SC problems (Lim et al., 2017; Tseng and Bui, 2017; Tseng et al., 2021). There is an urgent need for firms to enhance the effectiveness of their sustainability efforts so that they can achieve additional competitive advantages, as the business environment is dynamic and unpredictable. This study examines the Taiwan-Vietnam textile industry, as this industry should focus on SSCM to overcome the difficulty it faces in realising sustainable development goals.

Previous studies have proposed that firms aim to gain economic and competitive advantages by minimising the impacts of disruption on their SCs (Aslam et al., 2018; Munir et al., 2020). However, these impacts still greatly increase and intensify economic losses in production and SSCM connectivity (Gölgeci & Kuivalainen, 2020; Pettit et al., 2019). Munir et al. (2020) discovered that firms often encounter disruptions that cause the sustainability efforts of an entire SC to suffer. Gölgeci & Kuivalainen (2020) stated that disruptions are becoming a major problem, as they threaten firms' long-term survival by shifting their conventional management style to one that is established in a sustainable business environment. Poursoltan et al. (2021) pointed out that disruptions may result from product defect disruptions and then solved the utility function to minimise the cost of the whole system. In summary, the consequences are serious if industrial disruption and ambidexterity indicators are not fully understood (Pettit et al., 2019). For instance, the crisis caused by the unprecedented pandemic augmented the geopolitical partition and severely interrupted SSCM practices. This crisis is pressuring firms to innovate, repurpose businesses and adapt their production and material consumption to quickly respond to the resulting sustainable SC problems, prevent disruption effects, enhance their capacity to utilise materials that are in short supply, and help the economy to recover (Lee and Trimi, 2021).

Thus, ambidexterity in SSCM is recognised as an important concept for firms to apply when overcoming disruption (Bui et al., 2021; Lee and Rha, 2016; Partanen et al., 2020). Kristal et al. (2010) argued that SC ambidexterity practices should exploit existing knowledge and explore novel knowledge to achieve sustainability goals. Aslam et al. (2018) stated that SSCM ambidexterity requires firms to be both agile and resilient when responding to short-term changes to achieve greater efficiency in the long term. Partanen et al. (2020) proposed that ambidexterity utilises firms' capabilities and existing information flows to improve their SSCM. Gomes et al. (2020) declared that attaining production sustainability requires that ambidextrous indicators be balanced to improve a firm's adaptiveness in terms of imitation within changing

environments. A focus on ambidextrous SSCM strategies, such as exploration and exploitation, institutional ambidexterity, financial aptitude, the integration of SC agility resilience, adaptability, and dynamic strategies, the relationship between knowledge utilisation and operative information technology, and SC partnerships is urgently needed to deal with unexpected disruptive events and sustain operational processes (Aslam et al. 2018; Syed et al., 2020; Tseng et al., 2020). Although previous literature has revealed some findings regarding firm performance, SC disruption scenarios and ambidexterity associations, few studies have investigated the role of ambidexterity in SSCM (Gomes et al., 2020; Tseng et al., 2021). For instance, Pillai et al. (2017) argued that reflexive SCs might cause an overflow of social capital and information processing within conventional relationships, resulting in delayed organisational adjustments that lower disruption resistance. Bui et al. (2021) reviewed the literature on ambidexterity scrutinization; however, they overlooked the strongest indicators and did not include the effects of these indicators on SSCM performance. Although previous studies have examined the main concepts regarding ambidexterity and have obtained support for the SC system, studies examining firms' ambidexterity as an input of SSCM performance and a way to avoid SC network structural redundancy are lacking (Sahi et al., 2020; Bui et al., 2021). Thus, firms urgently need to implement an integrated assessment that identifies pathways for recovery during and after disruptions while maintaining their SSCM performance. Hence, this study offers a data-driven method to depict SSCM that identifies indicators of in industrial disruption recovery and ambidexterity that may be used to improve SSCM.

The literature has measured various topics related to ambidexterity, including cooperative innovation, product modernisation, SC capability and firm performance (Bustanza et al., 2019; Tseng et al., 2019). In summary, a data-driven approach has the potential to analyse and organise SC networks to promote SSCM performance (Shamsuzzoha et al., 2020). Firms face serious threats to their SSCM and operational effectiveness in uncertain environments and challenging markets (Liao et al., 2019; Munir et al., 2020). Firms must establish an ambidextrous structure that contributes to the development of more efficient and effective systems (Partanen et al., 2020; Lukoschek et al., 2018). However, this approach to structural ambidexterity lacks the effective organisational cognitive measures required to create distinct competitive advantages in SSCM (Bustanza et al., 2019). Since SCs have suffered from uncertainties due to sustainability requirements and have lacked effective competitive advantages (Tseng et al., 2019, Syed et al., 2020), this study proposes a hybrid method that merges data-driven analysis, the fuzzy Delphi method (FDM), and the cognitive best-worst method (BWM). The proposed data-driven technique is applied to identify SSCM indicators and compose an SSCM hierarchical structure based on big data sources (Tsai et al., 2020). The FDM is used to identify valid indicators from experts' linguistic references (Bui et al., 2020a, Tseng and Bui, 2017). The cognitive BWM is employed to determine and prioritise the best and worst indicators for the decision-making process to improve SSCM performance (Rezaei, 2015; Dong et al., 2021). Hence, this study's objectives are as follows:

- To identify data-driven SSCM indicators under SC disruption and ambidexterity.
- To construct a valid and reliable SSCM hierarchical structure through linguistic references.
- To prioritise SSCM indicators to improve the textile industry's SSCM performance.

This study has both theoretical and practical implications, which are as follows: (1) an SSCM

indicator set and hierarchical structure are established to extend the SSCM literature on industrial disruption and ambidexterity for decision-making; (2) practical directions are provided to aid firms in improving their SSCM performance; and (3) effective data-driven tools are provided to identify the most effective indicators. This study serves as a foundation for proposing and compiling the multiple benefits of structuring the literature on SSCM ambidexterity and textile SC capacity. The indicators in this literature shape SSCM responses in the context of disruption and provide the missing information links related to ambidexterity.

The rest of this study is arranged into five sections. The related literature on SSCM, SC disruption and ambidexterity, as well as the proposed method, are discussed in the second section. The third section addresses the methodologies in detail and proposes steps for analysis; additionally, the industrial background is presented. In the fourth section, the results are revealed, and then the implications of this study are discussed in the fifth section. Finally, the conclusion, study limitations and suggestions for future studies are provided in the last section.

2. Literature review

This section discusses SSCM under disruption, SC ambidexterity, the proposed analysis method, and the proposed measures.

2.1. Sustainable supply chain management under disruption

SSCM is defined as the management of the materials, capital, and information flow involved in SCs, as well as the cooperation and collaboration among SC players, namely stakeholders, suppliers and customers, and the implementation of all the sustainable development goals related to the economic, social, and environmental dimensions (triple bottom line; TBL) (Seuring and Muller, 2008; Tseng et al., 2021). Carter and Rogers (2008) described SSCM as the strategic integration of the TBL into systematic business processes to enhance the long-term synchronisation of a firm and its SC. Ahi and Searcy (2015) described SSCM as an SC cooperative design consisting of TBL integration that efficiently and effectively controls product/service procurement, manufacturing, and value delivery to meet stakeholders' requirements and improve firms' effectiveness, resilience, and competitiveness in both the short term and long term. SSCM is essentially an endeavour to integrate sustainable development into SCs. Rajeev et al. (2017) argued that SSCM requires coordination, collaboration, and information connectivity among SC networks to achieve higher organisational SC sustainability performance. Thus, incorporating sustainability concepts into SCs is essential for firms to achieve competitive advantages, especially in dynamic environments.

However, sustainability also has undesirable effects on firm turnover, indicating a need to exploit the performance advantages of implementing sustainability practices (Esfahbodi et al., 2017; Poursoltan et al., 2021; Tseng et al., 2020). The complexity of the dynamic business environment has resulted in vulnerability and various risks for SCs (Munir et al., 2020). Sustainability is becoming more crucial for SCs due to the uncertainty that has been created by disruption, as undesired and unexpected events such as economic crises, natural disasters, industrial accidents, technological shifts, and political catastrophes, including terrorist attacks and pandemics, occur more frequently and are more severe (Jajja et al., 2018; Gölgeci and Kuivalainen; 2020). These SC disruptions have highlighted the importance of post disruption management in identifying the relevant issues for mitigating risk and ensuring firm survivability. Laine and Galkina (2017) noted the effects of trade agreements on the capability of firms to adjust their

import/export dependence when responding to major disruptions. Jajja et al. (2018) showed the effects of environmental regulations, communal institutes, and resource abundance on the ability of firms to deal with disruptive conditions.

Thus, the current challenge is integrating firms' abilities to enhance their sustainable competitive advantages under disruption and ambidexterity (Yusuf et al., 2020). Dubey et al. (2019) argued that firms are now facing higher levels of risk because disruptions substantially affect SC performance; thus, firms must adapt by adopting changes that lead to the most advantages related to recovery. Gölgeci and Kuivalainen (2020) suggested that strategic interorganizational and intersectional relations within SCs are important in handling disruptions and difficulties. Previous studies have attempted to prepare integrated schemes that are adaptable and able to respond to, recover from, and endure disruptions (Linkov et al., 2018). Although SSCM has become a prominent field in response to business challenges, the current propositions, which focus on SC capabilities and developments, are not adequate for firms to achieve more beneficial market positions (Munir et al., 2020; Bui et al., 2021; Zhao et al., 2021). While it has been argued that SSCM offers competitive advantages and economic benefits, these improvements usually come with many unexpected risks due to the procedures required to adopt SSCM and the inconsistencies between new and traditional SC operations.

2.2. Supply chain ambidexterity

Ambidexterity is defined as a firm's efforts to harness and employ its current resources to establish new SSCM capabilities and improve its performance (Partanen et al., 2020). This concept refers to a firm's ability to simultaneously manage its opposition and conflicts and assess its goals to maintain competitive advantages and attain sustainable performance (Lukoschek et al., 2018). Shekarian et al. (2020) proposed that ambidexterity employs exploitation and exploration to reach long-term SC sustainability. In particular, exploitation aims to improve firms' main technologies or materials, while exploration aims to gather and assemble novel knowledge and information to innovate businesses (Zhao et al., 2021). Simeoni et al. (2020) argued that structural ambidexterity approaches should be managed separately, as to not obstruct each other. Indeed, sustainable SC ambidexterity has received extensive attention in the field of organisational theory (Gölgeci and Kuivalainen; 2020; Syed et al., 2020). It is generally agreed that ambidexterity entails sustaining firms' competitive advantages considering present and future performance. Venugopal et al. (2020) revealed that ambidexterity is substantially influenced by top management's interactive behaviours and the choices they make regarding practical innovation. Shamim et al. (2020) indicated that big data management abilities are related to ambidexterity through the big data value structure and employees' exploitative and exploratory actions. Simeoni et al. (2020) investigated firms' ambidexterity in the context of the sustainable development of fair trade schemes from a strategic exploitation and exploration viewpoint.

Furthermore, Bustinza et al. (2019) unpacked the strategic effects of ambidexterity on cross-country product/service innovation performance. Sahi et al. (2020) analysed strategic alignment possessions related to ambidexterity to improve firms' business performance from Industry 4.0. Syed et al. (2020) ascertained the ambidexterity of information technology contradictions and proposed that firm managers should improve their ambidexterity competence under uncertainty. Zhao et al. (2021) examined the role of governance ambidexterity in the influences of second-order societal wealth on green innovation. Lee and Trimi (2021) presented the concept of

sustainable convergence innovation in the context of the digital era and self-governing ecosystem crises characterised by distinctive life-cycle characteristics, advanced technologies, and innovative alignments for value creation. However, firms pursuing either sustainability or profitability may tackle challenges by specialising in either exploitation or exploration, but not both. The strategy of exploiting resources for economic benefits alone may become outdated over time, and companies may become incapable of reacting to changes, which can lead to immense difficulties.

Previous studies on ambidexterity necessarily consider firm management (Aslam et al., 2018; Bui et al., 2021; Zhao et al., 2021). Gomes et al. (2020) claim that there is a relationship between sustainable production and quality ambidexterity, as organisational sustainability requires production lines to be improved and simultaneously adapted to balance the TBL dimensions. Gomes et al. (2020) and Bui et al. (2021) argue that ambidexterity helps firms manage the business environment effectively while developing a sustainable SC system that can adapt to changes. However, the existing SC practices are inadequate in helping firms face disruption and gain additional benefits from SC ambidexterity (Syed et al., 2020; Tseng et al., 2020). The relationship between SSCM ambidexterity and disruption remains unclear, and empirical studies on ambidexterity are still limited, especially in the context of SCs (Bui et al., 2021). Studies on the capabilities necessary to develop ambidextrous SSCM competency in the context of disruption are urgently needed since SC resources must be more sustainably utilised.

2.3. The proposed method

In the literature, Gomes et al. (2020) used confirmatory factor analysis and fuzzy-set qualitative comparative analysis to explore the correlation between sustainable production and quality ambidexterity. Simeoni et al. (2020) adopted a qualitative and inductive approach in a unique context to analyse the organisational ambidexterity regarding the sustainable development of seven firms in a fair-trade system. Zhao et al. (2021) applied structural equation modelling to examine the role of governance ambidexterity of second-order social wealth and green innovation in maintaining sustainable development. However, uncertainty in a business environment requires firms to determine their ambidexterity capability level as well as the extent of their value generation. The multifaceted transformations in sustainable production and consumption demand that firms adopt an adaptation approach that is more disruptive than traditional operations (Bui et al., 2021). Previous studies have asserted that uncertainty might trigger ambidexterity-related effects for market orientation performance and prevent a firm from becoming operationally efficient but strategically inefficient (Syed et al., 2020; Sahi et al., 2020). The high level of risk involved in a disruptive scenario makes it difficult for firms to quickly identify the most effective indicators for better outcomes and their sustainable performance. However, there is no effective organisational cognitive approach to structural ambidexterity that creates distinctive competitive advantages (Bustinza et al., 2019). Thus, an appropriate tool is needed to evaluate the performance indicators that precede the innovation process, contributing to SC effectiveness and efficiency (Bresciani et al., 2018; Lukoschek et al., 2018; Simeoni et al., 2020).

Previous studies have measured various ambidexterity-related fields, such as cooperative innovation, product modernisation, SC capability, and firm performance (Syed et al., 2020; Bui et al., 2021). This approach combines novel ideas, resources, and knowledge and requires an innovative, data-driven method to exploit its complex results. Shamsuzzoha et al. (2020) adopted

a data-driven approach to SSCM in the context of a central logistics system employed by distributor firms. Kuo et al. (2021) applied a hybrid data-driven method to analyse cooperative material resource management strategies in the context of smart SCs and Industry 3.5. Since SCs face uncertainty when adopting sustainable practices and pursuing effective competitive advantages (Tseng et al., 2019, Syed et al., 2020), this study proposes a hybrid of two data-driven techniques, the FDM and the cognitive BWM, to illustrate a clear SSCM structure and identify the indicators that can enhance the effectiveness of sustainable SC ambidexterity under industrial disruption. This data-driven technique generates SSCM indicators from big data sources and composes an SSCM hierarchical structure (Tsai et al., 2020). The FDM is used to screen out the unnecessary indicators and validate the proposed structure based on experts' linguistic references (Bui et al., 2020a, Tseng and Bui, 2017). The cognitive BWM is used to determine the best and worst indicators for the decision-making process and improve the effectiveness of SSCM performance (Rezaei, 2015; Dong et al., 2021). Tseng and Bui (2017) used the FDM to refine and validate indicators for enhancing industrial symbiosis performance by computing their perception levels from experts' linguistic references. In particular, Bui et al. (2021) used data-driven analysis and employed the FDM to review SSCM trends under ambidexterity and disruption. Rezaei (2015) proposed using the BWM to solve multicriteria decision-making problems in the case of university students' choice of a mobile phone. Dong et al. (2021) proposed a fuzzy BWM to solve multicriteria decision-making problems under uncertainty, such as the problem of selecting a transportation mode or a supplier. The proposed method is appropriate for constructing a valid and reliable hierarchical structure and identifies the most important indicators for achieving effective performance. The advantages of the proposed method over the previous methods are addressed in Appendix A.

3. Method

3.1. Data-driven analysis

A data-driven approach has the potential to identify novel ways of organising and analysing SC processes and driving SC performance (Shamsuzzoha et al., 2020). In the context of SCs, data are used as the basis for quantitative and qualitative techniques aimed to improve SC competitiveness. Data act as a driver of improved decision-making and improved business performance for firms that can effectively leverage it. Previous studies have emphasised the exploration of SCs using literature components to illustrate the effectiveness of data sharing in the context of empirical practices (Bui et al., 2021; Kuo et al., 2021). This study uses the Scopus database to approach the SSCM literature due to the large amount of relevant data that this database offers (Tsai et al., 2020). Previous studies have approached the SSCM literature by employing data from the Web of Science, the Business Emerald Journals, ScienceDirect, PLoS, the JSTOR Archival Journals, the Social Sciences Citation Index, and the Science Citation Index (Koberg and Longoni, 2019; Rebs et al., 2019). However, these databases cover a smaller collection of publications, while Scopus offers much more academic literature data, such as engineering, social science and scientific journals.

Content analysis is adopted as an instrument to search the database based on systematic scanning or inspection of its artefacts or texts (Hodder, 1994). This technique produces efficient literature reviews by tracking text distributions. Additionally, it thoroughly delineates the articles by placing word and text sizes into predefined categories and employs text mining to collect

information for textual data classification (Tsai et al., 2020). Content analysis is a critical step when extracting information from a large amount of data in a systematised and efficient way, as it accurately collects information related to the identified themes, topics and methods with laborious approaches (Bui et al., 2021). First, this study uses content analysis to predefine the search terms used to assess the SSCM ambidexterity literature related to industrial disruption in the Scopus database. These enquiries were performed on October 10, 2020, using the search terms (“supply chain”) and (“ambidexterity” or “disrupt*” or “crisis” or “crises” or “chaos” or “interrupt*”) to search titles, abstracts, or keywords. The search margin was restricted to English-language articles, and reviews with no chronological constraints were included.

This study uses VOSviewer version 1.6.11, an open-source software, to scientifically classify related articles into clusters that define their relationships (Eck and Waltman, 2018). This study uses the software to collect information such as titles, abstracts, and keywords from articles, and to obtain probable indicators from the database. These indicators are collected through a cooccurrence coupling analysis of author keywords extracted from Scopus (Tsai et al., 2020). The VOS clustering technique is then employed to group these indicators into clusters (Eck and Waltman, 2018). Each cluster is a set of items labelled with a cluster number. These clusters are nonoverlapping, and each item is included in only one cluster. Bui et al. (2021) used this method to identify SSCM indicators based on publication data in the Scopus database. Furthermore, Bui et al. (2020b) used the VOS clustering technique to identify opportunities and potential directions for sustainable corporate finance.

3.2. Fuzzy Delphi method

This study combines fuzzy set theory and the traditional Delphi method to reduce data collection time and the size of the respondent sample, improving the efficiency of the analysis while offering precise and in-depth results (Tsai et al., 2020). This approach is used to refine the valid criteria based on the linguistic preferences of interviewed experts (Bui et al., 2020a, Tseng et al., 2019). These experts were asked to provide their sentiments about each criterion’s level of effectiveness. Expert a was asked to evaluate the effectiveness that indicator b affords to a system as $j = (x_{ab}; y_{ab}; z_{ab})$ and $a = 1, 2, 3, \dots, n; b = 1, 2, 3, \dots, m$, where the j_b weight of b is denoted by $j_b = (x_b; y_b; z_b)$ with $x_b = \min(x_{ab})$, $y_b = (\prod_1^n y_{ab})^{1/n}$, and $z_b = \max(z_{ab})$. Formally, the experts’ linguistic preferences were converted into triangular fuzzy numbers (TFNs), as shown in Table 1.

INSERT Table 1 HERE - Transformation table of linguistic terms for FDM.

Then, the convex value D_b is computed as follows:

$$D_b = \int(u_b, l_b) = \delta[u_b + (1 - \delta)l_b] \quad (1)$$

where u_b and l_b are obtained using a δ cut as follows:

$$\begin{aligned} u_b &= z_b - \delta(z_b - y_b), \\ l_b &= x_b - \delta(y_b - x_b), \quad b = 1, 2, 3, \dots, m \end{aligned} \quad (2)$$

The value δ ranges from 0 to 1 based on the positivity or negativity of a specific perception. The value is usually designated as 0.5 to denote an average situation.

The threshold of refining the valid indicators is computed as $t = \sum_{a=1}^n (D_b/n)$. If $D_b \geq t$, indicator b is accepted. Otherwise, it must be rejected.

3.3. The cognitive best and worst method

The BWM is employed to measure and prioritise the best and worst indicators for the decision-making process (Rezaei, 2015; Dong et al., 2021). This study utilises the BWM to solve cognitive problems by measuring the effectiveness and ineffectiveness of each indicator based on the respondents' evaluations using a 9-point scale ranging from [0,1]. A set of indicators is considered for the analytical process as $\{c_1, c_1, \dots, c_n\}$, and the best (most effective) and the worst (least effective) indicators are generally determined.

The weight of each indicator is calculated to justify its effectiveness and ineffectiveness as follows:

$$A_{Bn} = (x_{B1}, x_{B2}, x_{B3}, \dots, x_{Bn}) \quad (3)$$

where A_{Bn} denotes the best-to-others vector and x_{Bn} represents the preference of the most effective indicator B over the n^{th} indicator.

$$A_{nW} = (x_{1W}, x_{2W}, x_{3W}, \dots, x_{nW})^T \quad (4)$$

where A_{nW} denotes the others-to-worst vector and x_{nW} represents the preference of the least effective indicator W over the n^{th} indicator.

The optimal weight $(w_1^*, w_2^*, \dots, w_n^*)$ for the criteria is denoted by each pair of $\left(\frac{w_B}{w_n}\right)$ and $\left(\frac{w_n}{w_W}\right)$.

The cognitive BWM linearly minimises the maximum of the set $\left\{\left|\frac{w_B}{w_n}\right|, \left|\frac{w_n}{w_W}\right|\right\}$, and the maximum absolute difference (MD) of all the sets of m criteria is minimised as follows:

$$MD = \left(\left|\alpha_n - \frac{w_B}{w_n}\right|, \left|\beta_n - \frac{w_n}{w_W}\right|\right) \quad (5)$$

where (α_n, β_n) is computed as $\alpha_n = \left(\frac{w_B}{w_n}\right)$ and $\beta_n = \left(\frac{w_n}{w_W}\right)$.

The min-max model is arranged as follows:

$$\left\{ \begin{array}{l} \text{for min } \varepsilon \\ \left| \alpha_n - \frac{w_B}{w_n} \right| \leq \varepsilon \\ \left| \beta_n - \frac{w_n}{w_W} \right| \leq \varepsilon \\ \sum_{n=0} w_n^* = 1 \\ w_n^* \geq 0 \end{array} \right. \quad (6)$$

Hence, $(w_1^*, w_2^*, w_3^*, w_4^*, \dots, w_n^*)$ are identified at the optimal value of ε .

The consistency ratio (CR) is computed as follows:

$$CR = \varepsilon / CI \quad (7)$$

where CI denotes the consistency index, which is the maximum possible value of ε ($max \varepsilon$) (Rezaei, 2015). The (CR) ranges from 0 to 1 based on the consistency of the indicator group, and the closer the value is to 0, the more consistent the indicators are. The global weight of all the indicators is computed, and each indicator is ranked. An average cut (A) is used to determine

which indicators improve the performance effectiveness. This study employs the cognitive values from the valid FDM value of each indicator to identify the most effective and ineffective indicators.

3.4. Analytical steps

The analysis processes are presented in Figure 1. The analysis steps are as follows:

- (1) Search term identification: A search term is identified with which to collect publication information from the database.
- (2) Big data-driven and indicator generation: The SSCM indicators regarding disruption and ambidexterity are generated from the database, and content analysis and clustering techniques are employed to categorise these indicators into related groups. Content analysis is employed to generate the keyword as SSCM indicators, while the clustering technique is used to group the indicators into categories, in which each category is represented as one aspect to compose the study's hierarchical structure.
- (3) Hierarchical model validation: The experts' evaluations of the proposed indicators are obtained using the questionnaire. The FDM is used to screen the invalid indicators and validate the hierarchical structure.
- (4) Effective indicator prioritisation: A cognitive BWM is employed to measure and prioritise the effectiveness of the indicators for performance improvement.

INSERT Figure 1 HERE - Analytical procedure

4. Results

4.1. Data-driven analysis results

This study uses a content analysis approach to search the database and ascertain the distribution of the SSCM literature based on the titles, abstracts, or keywords of the documents in the database. A co-occurrence coupling analysis of author keywords is performed to extract the SSCM indicators from Scopus. There were 84 keywords listed 10 or more times in the occurrence counting analysis, and these keywords were categorised into 8 clusters that were then regarded as 8 criteria groups. Detailed emphasis labelling was conducted as shown in Appendix B.

Cluster 1 constructs a sustainable SC network design by creating SC networks through risk exploration. It includes the criteria related to SC competition, conditional value-at-risk, disruption and disruption risk, dual sourcing, facility location, inventory control and management, machine learning, pricing, procurement, production, purchasing, and reliable supplier selection. Cluster 2 is largely composed of information related to SC uncertainty. This cluster comprises factors such as business continuity, collaboration, contingency planning, corporate social responsibility, crisis management, energy security, governance flexibility, information technology, optimisation and outsourcing. The inclusion criteria for Cluster 3 are related to the information technology flexibility associated with big data, blockchain technology, disruptive innovation, global SCs, Industry 4.0, innovation, the Internet of Things, knowledge management, operations management, SC flexibility, and technology. This cluster mainly focuses on the flexibility gained from information technology that helps firms improve their SSCM performance in the context of disruption and ambidexterity. Cluster 4 focuses on sustainable partnerships. This cluster mostly concentrates on the relationships among SC members and includes asymmetric information,

chaos, closed-loop supply chains, complexity, coordination, demand disruption, demand uncertainty, disruption management, and dual channels. Cluster 5 focuses on SC risk assessment and involves disaster management, humanitarian logistics, risk management, risk mitigation, SC security, SC integration, SC risks, SSCs, transportation, and vulnerability. This cluster emphasises the need for SSCM to provide ways for firms to empirically build and test their risk management to mitigate disruption. Cluster 6 comprises SC resilience. This cluster contains criteria related to the bullwhip effect, information sharing, recovery, the ripple effect, SC collaboration, SC dynamics, SC resilience, and system dynamics. Cluster 7 comprises topics related to financial vulnerability, which concerns financial crises, SC disruptions, SC finance, SC risk management, and SC vulnerability. This cluster emphasises the financial and monetary issues related to SSCM and addresses the potential financial risks that result from industrial disruption and ambidexterity. Cluster 8 comprises SCF studies related to environmental resilience, which concerns climate change and resilience in sustainable development.

4.2. Empirical test – Textile industry application

This study examines the textile industry as the subject for an empirical application of the data-driven hybrid approach. The textile industry has achieved an average growth rate of approximately 30 percent per year, and it accounts for 20 percent of Vietnam's total exports (Wang et al., 2020). Indeed, the textile industry is highly competitive in the context of international trade integration, and its relative advantage is one of the factors promoting foreign trade relations, trade and exchange among countries around the world. Low labour costs, abundant labour, and skilful industriousness are some of the advantages that it enjoys. Because of this industry's competitiveness, its integration with technology development, its increasingly skilled workforce, and the incentives that it receives from government policies, the Taiwan-Vietnam textile and garment industry has greatly developed, completely meeting the needs of major markets such as the United States, Europe, and Japan and even reaching out to some other potential markets such as China, Korea, New Zealand, and Russia. The industry has followed a trend towards increasing sustainability, as pollution reduction and sustainable development are key ways the fashion and textile industry can maintain its competitive edge (Lim et al., 2017; Tseng and Bui, 2017). It is essential to avoid pure processing, such as buying raw materials and semifinished products. However, this industry still has many limitations. The fashion and textile industry has been able to produce raw materials to meet the demands for quality and product diversification. Knowledge of this industry's background serves as a foundation for proposing and implementing activities to apply effective SSCM, as ecological and human safety practices to strengthen the industry's capacity for this type of management in Vietnam are limited. The dynamics of how sustainable practices shape diverse responses to disruption are not well understood (Ho and Watanabe, 2020; Lin et al., 2019).

In addition, Taiwan-Vietnam's textile industry has not deeply participated in the global SC, and its outsourcing businesses mainly follow customers' instructions regarding raw materials. The industry suffers greatly from crises due to having an unsustainable supply. Raw materials from China and decreases in the consumption demand of major markets have led to disruptions and a decline in the number of imports and exports. For instance, the COVID-19 pandemic caused the demand from major customers in textile-importing countries to decrease by 70 percent during the first half of 2020 due to a sharp decline in consumer demand. Nearly half of the textile

SCs depend on market demand from countries that have been subjected to severe restrictions; this has resulted in a sharp decrease in retail sales and disruptions to the importing of raw materials for production (Vietnam Ministry of Industry and Trade, 2020). Although Vietnam is one of the countries successfully controlling the spread of the pandemic and the country's government has actively responded to the crisis, many firms have either temporarily or permanently closed due to global market influences. Workers have taken temporary leaves and the number of layoffs has increased; additionally, factories that have resumed operations are functioning with fewer employees. This threatens the sustainability of the textile industry. To address this situation, Taiwanese textile firms need to rapidly transform from traditional production methods to processes that can be adapted quickly; additionally, they need to implement new changes to their SC structures suited to the new situation. Firms urgently need to improve the effectiveness of their sustainability efforts since the business environment is dynamic and uncertain. This study contributes fundamentally to structuring the effectiveness of SSCM ambidexterity for the textile industry since the indicators that shape SSCM responses to industrial disruption and ambidexterity are not well understood.

A committee of scholars and professionals with at least 9 years of experience, study, and work history involving SSCM were assembled for the qualitative evaluation, including 14 experts from academia, 8 experts from government offices and non-government organisations, and 11 experts from the practical field of the textile industry.

4.2.1. Fuzzy Delphi method results

In this study, the FDM is conducted over 2 rounds. A face-to-face interview with the expert committee is employed to refine the keywords to be used as the proposed criteria for analysis. Round 1 aims to eliminate the irrelevant criteria, and round 2 allows the experts to modify the sentiments based on the results of round 1. The process allows experts to inform their evaluations through quick aggregation by revising their sentiments regarding validating the criteria set (Bui et al., 2020a).

From the data-driven analysis, 84 criteria are selected for evaluation with the FDM. This evaluation is based on the experts' experience and opinions, and the linguistic terms are converted into corresponding TFNs, as shown in Table 1. Then, the FDM is employed to screen out the irrelevant SSCM criteria with the threshold $\gamma = 0.306$, as presented in Appendix C. A total of 43 keywords are accepted for the second stage of the FDM. During the second stage, the experts can reconfirm their judgements when validating the criteria set (Bui et al., 2020a). Nineteen out of 43 keywords are eliminated with the threshold $\gamma = 0.341$, as presented in Appendix D. A set of 7 aspects and 24 criteria remain as a valid hierarchical structure for SSCM under industrial disruption and ambidexterity, including SC network design (A1), SC uncertainty (A2), information technology flexibility (A3), sustainable partnership (A4), SC risk assessment (A5), SC resilience (A6), and financial vulnerability (A7), as listed in Table 2.

4.2.2. Proposed measures

The SSCM indicators under disruption and organisational ambidexterity are determined from the FDM results, as shown in Table 2.

The recent evolution of sustainability has been based on a thorough understanding of the

wide-ranging and diverse SSCM literature (Zhao et al., 2021; Rajeev et al., 2017). Thus, an innovative indicator set is needed to allow for advanced SSCM performances (Bui et al., 2021). From the literature, this study has compiled a set of indicators consisting of seven aspects and 24 criteria, including SC network design, SC uncertainty, information technology flexibility, sustainable partnership, SC risk assessment, SC resilience, and financial vulnerability.

Integrating sustainability into SC design is necessary for developing a comprehensive approach to SSCM (Türkay et al., 2016). The SC network design (A1) embodies the facility location problem since, in practice, the SC includes facility location resolution, network extent capabilities, and material flow monitoring within the facilities' systems (Bui et al., 2021). Ambidexterity is achieved by networking both inside and outside a firm's boundaries (Ferraris et al., 2017). Facility location planning (C1) in the context of logistics systems is important for value distribution, developing an appropriate facility location design, and maintaining cost-effectiveness (Wang and Ouyang, 2013). It is argued that reconfiguring the SC network design requires both short- and long-term strategies to recover SC performance (Bui et al., 2021). Sourcing strategies can react to an actual shortage, serve as proactive plans for potential scarcity, and involve contingent suppliers. Thus, inventory control strategies (C2) are considered proactive techniques to justify ambidexterity by involving ordering and stocking decisions (Partanen et al., 2020). Firms select their ambidexterity alliances through a combination of different inter- and intraorganizational connections (Bresciani et al., 2018). Supplier selection (C3), which is recognised as one of the most critical procedures in the obtaining function of supply management, must be adaptive, as it must be able to adjust when the total cost of risks is instantaneously reduced under demand fluctuations, risk and disruptions (Kaur and Singh, 2021)

Uncertainty occurs in unclear circumstances that cannot be addressed straightforwardly, using a certain amount of information to depict the different possibilities arising from an unascertained situation (Liao et al., 2019). Uncertainty and diversification are important when reacting to SC variations. Uncertainty and a lack of information threaten firms' activities and sustainable existence, and firms need quality and reliable information and must engage in innovative actions to deal with frequently changing, complex, and uncertain environments (Munir et al., 2020; Bui et al., 2021). Business continuity (C4) is an inclusive management procedure by which firms can identify potential threats and their possible influences on business operations (Xing et al., 2019). Energy security (C5) indicates the continuous availability of energy sources at an affordable price (Martišauskas et al., 2018). Outsourcing (C6) represents moving or relocating jobs or projects to another firm or country. These concepts offer an outline for an organisational structure with an effective response capability that can guarantee key stakeholders' benefits, firms' reputations, and value-creation accomplishments (Pereira et al., 2019; Xing et al., 2019).

Based on information technology flexibility (A3), ambidexterity should be present in individual firms and SCs (Han et al., 2017). This concept regards the linkages among SC networks and allows firms to utilise their existing cross-organisation manoeuvres and supplier management arrangements to restructure their procedures to improve their efficiency. Information and communication technology and knowledge management capabilities are two discrete and decisive capabilities for enhancing ambidexterity performance (Bresciani et al., 2018). In particular, the blockchain (C7), a decentralised, digital platform that enables peer value transfers such as digital currency and physical commodities, could facilitate SC exploration

practices across business entities and be used to detect customer trends and develop new product offerings (Han et al., 2017). Industry 4.0 (C8), which is characterised by the Internet of Things, cloud computing, and big data, is associated with digital tools and methods that radically modify society and industries (Abdul-Hamid et al., 2020). The Internet of Things (C9) allows engagement in and influences intelligent controlling procedures and related business activities for production efficiency by revitalising the drivers of efficiency and technologically designing and reengineering inventiveness in disruptive businesses and even economies (Carayannis et al., 2018). However, it is argued that in the current digital age, modernisation does not correspond to technology-enabled mechanisation at the economic scale; this is demonstrated by the pioneering industrial paradigm of mass production that requires a creative push, integration, or synthesis of things, knowledge, ideas and technologies to generate numerous outcomes and strategic possibilities (Lee and Trimi, 2021). Technology in disruptive SCs engenders change within knowledge-driven firms, and higher density contributions can create a stable knowledge-sharing network that encourages close communication within SCs to allocate inferred information and technologies (Zhao et al., 2021). Thus, knowledge management (C10) is a cohesive approach to classifying, evaluating, capturing, salvaging, and sharing information, and it increases the reliability and improves the performance of the advanced technological criteria utilised in SSCM (Lim et al., 2017). Individuals and firms must rely on information technology resources and synergy with technical knowledge assets to increase their operations' efficiency and economic benefits (Syed et al., 2020).

The balance between inter-organisational ambidextrous exploration and exploitation is accomplished by individual partner organisations (Bui et al., 2021). Sustainable partnerships (A4) represent a form of resource fortification involving prompt cooperative processes and help firms prevent unexpected disruptions (Simeoni et al., 2020). Network development within and outside firms' boundaries potentially increases ambidextrous performance (Bresciani et al., 2018). However, the interconnections among SC partners are associated with SC risk and probably result in a sequence of disruptions that threaten SSCM practices (Bui et al., 2021). For instance, asymmetric information (C11) reflects a difference between the demands of downstream participants and the involved suppliers' costs and contract designs (Lan et al., 2020). Therefore, trust and resource sharing mechanisms designed to avoid organisational conflict and manufacturing inconsistencies among SC partners must be highlighted. Synchronised coordination is a significant issue. SC coordination (C12) manages the dependencies among SC partners and the joint effort to work together towards mutual goals (Zhao et al., 2020). However, excessive coordination increases the complexity and negative effects, as it introduces harmful concurrences or even SC interruptions (Munir et al., 2020). Demand disruptions (C13) are demand instability where risk increases or decreases market demand (Zhao et al., 2020). If upstream participants adopt a standard policy capacity to avoid demand uncertainty, downstream participants must address a supply shortage to satisfy the market; thus, the total benefits of both the manufacturer and the buyer are diminished, resulting in poor performance. The disruption management (C14) approach, which involves a change in the initial plan, creates a need for a replanned resolution to manage SC disruption events (Wide, 2020).

The dynamic complexity of business environments results in vulnerability due to the various SC risks that arise from the disturbance caused by resources, products, financial flows, and information that interrupt firms' ordinary operations (Gölgeci & Kuivalainen, 2020; Shekarian et

al., 2020). This remains a main administrative challenge that negatively affects firm performance. SC risk assessment (A5) occurs when SC partners attempt to identify and manage risk to reduce SC vulnerability (Shah et al., 2020). A substantial number of criteria are used in integrated planning systems that can enable the creation of ways to endure, respond to, recover from, and adapt to risks (Linkov et al., 2018). Disaster management (C15) is viewed as a key approach and an effective strategy to minimise a disaster's impact. This approach is a type of strategic planning and a process employed to maintain critical infrastructures and assets from serious consequences when man-made catastrophes and natural disasters occur (Shekarian et al., 2020). Furthermore, identifying the factors relevant to diminishing risk and guaranteeing firm survival should be prioritised (Bui et al., 2021). The development of risk mitigation (C16) strategies must be pursued, as these strategies allow the effect of potential risk on the total SC disruption to be forecasted (Munir et al., 2020). SC integration (C17), namely, conscious cooperation within SC alliances, might synchronise the operational practices related to the distribution of products/services, information flow and joint decision-making in various functional domains both inside and outside firms' boundaries (Shah et al., 2020). Firms should ascertain the association between risk assessment and SC integration to improve their sustainability performance during unexpected disruptions and uncertainty when designing their operational processes.

SC resilience (A6) represents the adaptive capability of supply chains to respond to, and subsequently recover from, unexpected events and disruptions by smoothly continuing their operations and balancing their connectedness through firm structure and SC functions (Gölgeci & Kuivalainen, 2020). Resilience is required for firms to survive despite efforts to mitigate the negative effects caused by environmental changes (Bui et al., 2021). In particular, the bullwhip effect (C18), which is associated with operational dynamics and intensifies ordering fluctuations upstream, and the ripple effect (C20), which is associated with structural dynamics and designates a downstream downscaling spread in demand fulfilment, may result in severe disruptions (Munir et al., 2020). In this context, resilience is crucial for firms when addressing the challenges, uncertainties, and numerous crises and disruptions they face, generating sustainable value for SCs (Gölgeci & Kuivalainen, 2020). However, it is unclear how SC resilience can be established and whether it enhances firm sustainability (Bui et al., 2021). High resilience is important for balancing firms' capability enhancement and the additional costs associated with managing vulnerabilities (Pettit et al., 2019). In particular, recovery (C19) is concerned with SC stabilisation and dynamic modifications of resource distribution to guarantee operational stability (Gölgeci & Kuivalainen, 2020). Thus, models designed to measure SC resilience and enable firms to sustain high-performance levels under disruption must be constructed. The construction of a system dynamics (C21) (SD) model as a tool to define, expose, reproduce and analyse the dynamic propensities of composite systemic problems, investigate strategies and explore emerging circumstances should be a part of this endeavour (Gröne et al., 2019).

Financial vulnerability (A7) is an efficiency gap originating from insufficient incorporation of a domestic economy into international markets and establishes the case for welfare that improves the reactions of the central bank to currency fluctuations (Lee et al., 2020). This leads to financial crises (C22) partially disintegrating into vulnerability shocks or constituent imbalances, which are possibly rigorous disruptions of financial markets that damage markets' abilities and firms' effective functions (Lee et al., 2020). Indeed, disruptions inflict financial damage to connected firms, resulting in large financial losses and operational changes that harm their

reputation and business prestige, possibly leading to bankruptcy. Adopting SC finance (C23) is argued to promote market utilisation and improve firms' financial performance, subsequently improving their competitive advantages (Bui et al., 2021). It is argued that this approach decreases operational costs, generates more income for SCs, and promotes sustainability because this financial mechanism involves more commercial transactions that diminish the negative effects of disruption and produce additional sustainable value. However, an SC finance-oriented consideration that ensures the extension of payment terms while harming suppliers can lead to upstream SC disruptions (Bui et al., 2021). This SC vulnerability (C24) appears as an uncovering or predisposition to a disruptive event in an SC and introduces undesirable consequences (Shekarian et al., 2020). As a result, suppliers that face financial deterioration could discontinue production; additionally, downstream firms within such an SC are harmed due to the resulting credit catastrophe and struggle to satisfy the market demand.

The current understanding of disruption and ambidexterity in the context of SSCM is still limited; this results in inferior data once disruptions are informed (Lee and Rha, 2016; Sahi et al., 2020). These catastrophic incidents are mainly unforecastable due to limited warnings, and their effects are difficult to forecast until they occur. Firms with higher levels of market power tend to overcome these events; however, SC disruptions might strain their continuance capacity. Firms need to gain and integrate different types of knowledge to sustain their ambidexterity portfolio efficiently and effectively (Bresciani et al., 2018). Sustainability is deemed a strategic way to gradually improve organisational competitiveness and balance acquisitions within SCs (Simeoni et al., 2020).

INSERT Table 2 HERE – Proposed hierarchical structure

4.2.3. Cognitive best-worst method results

This study employs the cognitive value of the valid FDM value of each criterion to identify effective and ineffective indicators. For example, regarding aspect A1, the best and worst criteria are C1 and C3, with FDM weights of 0.446 and 0.341, respectively (shown in Appendix D). The experts are then asked to evaluate the value contributed by the best criterion in each group and the worst criterion in the group as pairwise comparisons, as shown in Table 3.

INSERT Table 3 HERE - Cognitive best-worst method results for the aspects

The results show that the *CR* values of all the aspects are less than 1, which indicates the consistency of the indicators and confirms the validity and reliability of this study's hierarchical structure, as shown in Tables 4 and 5. The global weight of all the indicators is computed, and each indicator is ranked. The consistency of the indicators is also confirmed ($CR = 0.119$). An average cut of (A) = 0.143 is computed to indicate the most important aspects. These aspects include financial vulnerability (A7), SC uncertainty (A2), risk assessment (A5), and supply chain resilience (A6); these are drivers that are guaranteed to ensure SSCM effectiveness under industrial disruption as well as ambidexterity (shown in Figure 2).

INSERT Table 4 HERE - Cognitive best-worst method results for the aspects

INSERT Figure 2 HERE – Aspect effectiveness diagram

Similarly, an average cut of $(A) = 0042$ is used to determine which criteria successfully enhance the performance effectiveness (Figure 3). This study determines that 12 criteria successfully enhance SSCM effectiveness. The best criteria, namely, financial crisis response (C7), business continuity (C4), SC integration (C17), bullwhip effects (C18), facility location (C1) and supplier selection (C3), are highlighted as vital practical concepts for firms to focus on during crises.

INSERT Table 5 HERE - Cognitive best-worst method results for each criterion

INSERT Figure 3 HERE – Criteria effectiveness diagram

4.2.4. Data saturation

Failure to achieve data saturation harms the quality, validity and robustness of the study's results. Therefore, data saturation, as a sensitivity analysis, is used to confirm the robustness of the respondents and analytical findings by checking that there are no novel data or information encountered that significantly change the results (Fusch & Ness, 2015; Bui and Tseng, 2021). Guest et al. (2006) specified that data saturation is realised by accumulating six initial sample respondents, depending on the sample size. Fusch & Ness (2015) declared that there should be five to eight more interviewees after inspecting initial respondents. Thus, this study adds 7 more experts to supplement the data saturation testing (N=38) to confirm the study's validity and robustness.

The result confirms that there is no major fluctuation between the value of the initial result and the data saturation result, as shown in Figures 4-5. From the data saturation result, the effective aspects include (A7), (A2), (A5), and (A6), as shown in Table 6, while the number of effective criteria and top criteria still remain as (C7), (C4), (C17), (C18), (C1) and (C3), as shown in Table 7. Thus, the study's validity and robustness are verified.

INSERT Table 6 HERE - Cognitive best-worst method - data saturation results for the aspects

INSERT Figure 4 HERE – Aspect data saturation diagram

INSERT Table 7 HERE - Cognitive best-worst method - data saturation results for the criteria

INSERT Figure 5 HERE – Criteria data saturation diagram

5. Implications

5.1. Theoretical implications

With the rise of globalisation and easier integration for available SCs, the most important aspect of SSCM is how to balance supply, demand and competition in a limited market to decrease distinctiveness and increase complexity. In this context, if an SC needs to shift from crisis response to recovery, then the SC must focus on performance and cost management; additionally, firms may better prepare their SSCM for future disruptions based on their level of

security.

The financial vulnerability lies in asset expositions where SC risk craving and asset evaluation compressions may result in overestimating the value of assets; this can quickly justify a change in prices or undermine, disentangling the financial imbalance. In this situation, firms cannot efficiently disseminate resources within the financial system between operational actions and transverse time, and they cannot measure and control the financial risk; thus, their economic performance and SC accumulation will deteriorate (Lee et al., 2020). Unfavourable financial vulnerabilities in macroeconomic situations severely decrease fiscal market costs and influence other parts of SCs. A modification of the dynamic response to financial vulnerability shocks is needed to mitigate severely negative changes related to industrial production (Bui et al., 2021; Tseng et al., 2021). However, the associated risks and SC fragmentation of manufacturing and global multilayer supply network combinations in the context of disruption are largely ignored. There is a need to understand strategic SC gaps since corporate spillovers and the intensification channels of financial vulnerability are likely to spread from one sector to another. An ambidextrous global SC provides opportunities for firms to better identify ways to accomplish their business goals and sustainable strategies and ways to protect society throughout vulnerable periods. SC players may make specialised investments and thus be more efficient when obtaining information about investment opportunities and potential earnings from investments. It is argued that implementing SSCM in financially vulnerable firms helps firms overcome zero-sum situations in negotiations and enables firms to gradually utilise information sharing and connections to benefit exchanges. These financially vulnerable firms can make better decisions, obtain potential benefits through integrative SSCM, attain desired outcomes, generate more value, and establish efficient performance.

Uncertainty created by disruption threatens SC sustainability by causing undesired and unexpected events (Liao et al., 2019). In addition to benefits such as higher production, lower transaction costs, a greater focus on core business competencies, and a greater chance of achieving higher profits through sharing resources with SC partners, SCs also encounter many risks, such as uncertain demand, products that require a greater degree of diversification, increasing customer expectations, and the presence of many global competitors; these risks make SCs complex and difficult to predict. Firms must identify potential risks and their impacts on SC performance to be more proactive in coping with and preventing these problems while creating opportunities for businesses to turn risks into business opportunities to effectively implement SSCM. Business uncertainty requires that firms ascertain their level of ambidexterity competence to increase their sustainable value (Syed et al., 2020). Quality, reliable information is needed for firms to deal with dramatically changing environments and uncertain complexities (Bui et al., 2021; Munir et al., 2020). Multilayered SSCM transformations demand that firms make changes to be disruptive adaptation oriented rather than oriented towards traditional operations. A stable partnership that creates an alliance committed to a reduced product range and increased efficiency with high-quality service can encourage collaboration in terms of information sharing within an SC network to improve ambidexterity competence in the context of uncertainty.

The dynamic business environment has resulted in various SC risks (Munir et al., 2020). SC risk indicates any risk to the flow of information, materials or products from their original supplier to deliver the finished product to the end consumer. Risk is often associated with uncertain events, hazards or damages, as well as unintended outcomes that may cause a sudden impact on any

part of an SC, leading to failure at the operational, tactical, or strategic levels. A risk assessment seeks to reduce the number of SC gaps through a coordinated, holistic approach involving all SC stakeholders; this approach identifies and analyses the risks of SC failure points. Risk assessment can help structure an SC to minimise the effects of risk, as disruptions substantially harm SSCM effectiveness (Dubey et al., 2019). Mitigation plans to manage these risks may be related to logistics, cybersecurity, finance, or risk management, and they ensure SC continuity in scenarios that could disrupt business operations and profitability. Integrating all the stages of SC rotation to increase transparency, reduce costs, and improve operational efficiency and employing SC logistics techniques such as supply chain optimisation can preclude contingency planning and reduce the overall SC risk level. However, these processes may not be enough to ensure preparedness for every complex situation. SC resilience could be included to ensure that supply chains can recover from risks and that firms are familiar with most integrated systems to address and recover from losses when risks occur (Shekarian et al., 2020; Linkov et al., 2018).

Higher SC resilience enhances the capacity of SCs to cope with change. It improves the traditional centralised corporate structure to achieve a strong ability to prepare for unexpected events, respond to disruptions and recover from disruptions by maintaining continuous operations at a degree of connection and control that corresponds to the desired structure and function of the SC. This study confirms that firms that are both agile and resilient are more efficient when responding to short-term changes and can reach a higher level of SSCM ambidexterity (Aslam et al., 2018). SC resilience helps balance ambidextrous indicators, improve firms' imitating adaptivity to changing environments, and increase production sustainability (Gomes et al., 2020). The SC resilience network must be adjusted to accommodate the risks affecting its capabilities, including features such as reactive SC governance, internal SC alignment with planned buffers, extended SC collaboration, and thriving SC adaptation and flexibility. Firms must not only adapt at a single point in time during a crisis or have a flexible chain of responses but also anticipate risks and continue to adjust to disruptions that could permanently decrease their key business value. Therefore, ambidextrous strategies require continuous improvement, emphasising product structures, processes, and business behaviours. A focus on integrating the relationship between knowledge utilisation, the enhancement of firms' capabilities and SC partnership to deal with unexpected disruptive events and sustain operational processes is urgently needed (Bui et al., 2021; Syed et al., 2020).

5.2. Managerial implications

As an economy falls into a recession or instability, businesses face difficulties and challenges. One of the most important aspects to focus on is ensuring stable operations. This study highlights several important criteria as being vital and practical issues for firms to focus on during financial crises, namely, business continuity, SC integration, bullwhip effects, facility location, and supplier selection, which can help textile firms during the decision-making process in the context of industrial disruption and ambidexterity while also strengthening these firms' sustainable effectiveness.

During financial crises, firms often face problems when securing cash flows to repay debts, refinancing problems, and liquidity problems, each of which affects the firm's value creation. Implementation of a proper SSCM strategy can help firms become stronger during difficult times and after a recession ends. Firms need to outline risk control activities and balance the potential

profits of their SC partners. Firms should focus on crisis management and liquidity management and implement actions such as establishing a quick response team to deal with unusual problems that arise in terms of safety, supplies, and materials production. Firms should employ liquidity management as an effective solution to balance cash flows, reduce unnecessary expenditures and closely monitor liabilities. Solutions may include reviewing portfolios and selling or divesting them appropriately, reallocating investment resources to maximise efficiency, and optimising loans. In addition, firms should revise their product structures, customer structures, and price policies, revise their procurement and SC costs, optimise their taxes, and optimise their working capital. Firms could minimise their cash inventory by exchanging cross-functionalities to synchronise with their raw material purchases, the distribution of their raw materials and their product deliveries. Property procurement plans that account for shelving and alternatives, such as renting a property to maintain a sufficient cash substitute, are suggested.

Textile industry investments entail a great deal of uncertainty related to sudden breakdowns of the global trade value chain and weakening of production and exports. This affects the demand for consumption and investment, although material supplies like cotton and crude oil remain relatively stable and concentrated. Therefore, the importance of maintaining business continuity must be emphasised, as this industry is highly sensitive to external shocks, such as a decrease in import-export activities, including a decrease in important markets such as the United States, Europe, South Korea and Japan. Creating contingency scenarios, establishing predefined action plans to address potential unforeseen impacts, and creating an emergency operations centre to more effectively respond to the markets are required. State management agencies also play an important role in the operation of textile and garment clusters. Firms should also improve their business environment and infrastructure by investing in developments ranging from sustainable SC networks, including raw material, chemical, and export networks, to on-site human resource training and capital attraction. These actions are needed to ensure sustainable development during disruptions. Strict management styles must be replaced by state-of-the-art business opportunities that adapt quickly, flexibly, and dynamically according to changing business directions and strategies. Firms should adapt their selling processes and distribution channel-based digital platforms to reach and serve consumers from the manufacturing side and facilitate last-mile delivery businesses, as these are potential solutions to foster business continuity.

SSCM development in the textile industry requires sustainable SC integration with diverse support networks involving financial institutions, education, and infrastructure to provide raw material supplies, such as cotton, fibre, and chemicals. Nevertheless, Vietnam does not have a proper policy or strategy to address sustainable textile industry development yet; rather, this development has occurred mainly within individual firms with no connection to other organisations in the industry. Therefore, establishing a sustainable SC integration process has become more urgent than ever, especially under the current economic disruption. This can include determining the basic market supply strategy, connecting with other businesses, or identifying the appropriate tactics to employ. The roles of various functions, communication procedures and decision-making practices are related to coordinating SCs from yarn, weaving, dyeing and garment suppliers to downstream partners, such as logistic firms, distributors and retail channels and, finally, consumers. Focusing on internal synchronisation helps firms react quickly to environmental changes, thus achieving a greater ability to survive during downturns and realising certain advantages in terms of ambidexterity. Firms should establish reliable

connections when choosing long-term partners. Likewise, there is an urgent need to reanalyse existing partnerships to determine if these partnerships are still effective or justified in the current context. Firms can better understand instability during a crisis by closely connecting with their customers and suppliers; this can be done by building mutually trusting relationships and establishing exchange channels with firms in the SC network. These connections help in the timely sharing of information related to various issues, such as cutting costs or replacing materials as prices increase and developing plans to prevent unexpected events.

The bullwhip effect reflects the effect of the difference between the number of products produced and the actual demand. In other words, information about market demand is distorted or amplified across an SC, leading to an excess of inventory; this influences price policies and creates an inaccurate reflection of demand. In this situation, firms increase their production to satisfy demand, causing the output of these firms to be much larger than what the actual demand requires. As a result, a product surplus occurs because there is too much inventory, and the increased cost of transport and labour obligates firms to shut down machinery and cut staff; additionally, distributors have difficulty managing their inventory due to the large amount of buying and hoarding that has occurred. Due to a lack of updated demand data and transparency across the entire SC, retailers cannot maintain steady inventories at the minimum speed required to replenish the demand quantity, and the resulting spike in demand is distorted as it permeates the SC and threatens SSCM performance. Firms must realise the importance of increasing their resilience to adverse circumstances and controlling the potential increase in SC costs due to employing diversified sources to avoid failure or the transformation or recreation of their SCs. Sharing information about real needs with all the participants of an SC, improving SC communication and providing better forecasting may eliminate delays along with SCs. With a focus on using information technology to forecast end-user demand through point-of-sale income data, electronic data exchange, and supplier information, the implementation of inventory management is recommended to reduce errors in downstream communication. Firms should maintain stable prices for their products since price volatility encourages customers to buy more when the price is low and buy less when the price is high, causing fluctuations in orders. Developing a response plan to more deeply and broadly examine macro impacts, instead of focusing mainly on micro drivers, is required to establish flexible SSCM under disruption.

Facility location development enables transportation, communication systems, and digital infrastructure innovation and is important to the economy, society, and businesses' continued sustainable development. However, it cannot be achieved by individual firms or countries; rather, it requires global public-private partnerships. Restructuring the manufacturing SC, establishing mutually beneficial industry connections, identifying like-minded partners, and reorganising and strengthening the values and principles of alliances are needed. Firms need to focus on repositioning strategies, including reforming their business models, reviewing their growth models, diversifying their SCs, and reforming their feedback practices, to engage well and effectively with customer behaviour and demand. Additionally, telecommunications platforms need to secure more bandwidth to maintain business and resilience during crises since this approach has great potential for helping maintain connections between SC partners during periods of restriction and transitions to distance work and online learning. Applying robotics and artificial intelligence in SC operations and other business functions is suggested. There is a need for cooperation among governments, financial institutions and regulators to build adequate

facility locations that enhance the effectiveness of the textile industry's sustainability.

Many SC suppliers are participating in the modern commercial market. A firm can encounter a crisis due to a drop in sales caused by macroeconomic factors; this decline in revenue leads to a lack of solvency, making paying suppliers increasingly difficult. However, a lack of raw materials from suppliers may cause production to stop, reducing the amount of output and the number of products sold; this then leads to a decrease in revenue, which increases the possibility of a crisis even more. Supplier selection becomes more important for firms experiencing a disruptive scenario and in the context of ambidexterity. Firms need to establish a network map of suppliers as a practical strategy to handle crises. If an SC is dependent on one supplier, the risk that it faces will be higher. Firms redesign their SCs in the following two ways: (1) introduce a second source other than their main supplier to reduce their level of risk, even though this incurs higher administration, quality supervision and other costs, and their economic scales vary according to the amount of supply allocated to each supplier or (2) implement local resources as a supply for their production facilities, with local goods in each of the major markets the firm covers; this strategy helps businesses disperse risk and lowers transportation costs, but also requires higher conversion costs. Moreover, firms must carefully control the increase in their SC costs due to the diversified sources employed to avoid discontinuity or inaccessibility of the chain. It is also important to assess supplier risks, such as supplier reputation, quality of products/services, delivery performance, price and payment method, vendor customer service, and supplier financial risk, to avoid potential losses and evaluate their long-term performance and sustainability.

Currently, Vietnam is gradually transitioning from a crisis response phase to a recovery phase, and so now the key questions for textile SSCM are how to better prepare for future crises, ensure stable and synchronous operations, avoid risks, and reduce costs to overcome future crises.

6. Conclusion

The textile industry is one of the largest global industries and has recently been making progress in identifying the necessary indicators for implementing sustainable management concepts in SC networks. In recent decades, the number of SSCM studies has increased due to pressure caused by resource limitations and consumption activities, which have led to increasing waste and environmental contamination. Previous studies have failed to (1) generate data from databases and confirm the validity of effective indicators; (2) build a hierarchical structure with interrelationships under industrial disruption and ambidexterity; and (3) determine the necessary indicators for effective textile industry SSCM performance. This study identifies data-driven SSCM indicators under conditions of industrial disruption and ambidexterity by proposing a hybrid method that merges data-driven analysis, the FDM, and the cognitive BWM. This data-driven technique identifies SSCM indicators and composes an SSCM hierarchical structure based on big data sources. The FDM filters the valid indicators from experts' linguistic references. The cognitive BWM is employed to determine the best and worst indicators to prioritise in the decision-making process to improve SSCM performance.

This study collects and validates a set of indicators consisting of seven aspects, including SC network design, SC uncertainty, information technology flexibility, sustainable partnership, SC risk assessment, SC resilience, and financial vulnerability, and 24 criteria, establishing a valid hierarchical structure for SSCM under industrial disruption and ambidexterity. The results show

that the most important aspects are financial vulnerability, SC uncertainty, risk assessment, and supply chain resilience, which are drivers that are guaranteed to improve the effectiveness of SSCM under industrial disruption, as well as in the context of ambidexterity. The top 5 criteria, namely, financial crisis response, business continuity, SC integration, bullwhip effect, facility location, and supplier selection, are highlighted as vital practical tactics for firms to focus on.

This study contributes theoretical and practical implications by providing effective data-driven tools to identify SSCM indicators that are effective under industrial disruption and ambidexterity. Due to the uncertainty and vagueness of SSCM practices, this study proposes a method that uses the cognitive BWM as its core to derive an adjustment process for improving the consistency of the hierarchical structure and the identification procedure of the critical indicators for the decision-making process. First, an SSCM indicator set and hierarchical structure are used to enrich the SSCM literature on industrial disruption and ambidexterity, and practical directions are provided for firms to improve their sustainable, effective performances. This study contributes by proposing and compiling the multiple benefits of structuring the SSCM literature and the textile industry literature. The indicators in this literature shape SSCM responses, ensure stability and synchronous operations, and avoid risks under disruption and ambidexterity.

However, some limitations still exist in this study. The hierarchical structure in this study may not be comprehensive since the indicators used are taken from the Scopus database only. Future studies should include additional indicators from other databases or employ a cross data-driven analysis to conduct further examinations. Identifying what types of resources, skills and capabilities are needed and suggestions are provided for the types of ambidexterity, exploration or/and exploitation are applicable to the industry SCs. The results of this study are dependent on expert references, which may include prejudices due to their acquaintance with the study field; future studies should increase the sample size to overcome this problem. It is recommended that future studies apply the proposed structure to other industries or conduct a comparison among other countries or geographical areas to provide more generalizability. Furthermore, this study suggests integrating the proposed method with other methods to enhance the reliability of the results and the applicability and usefulness of the method for future studies. Since this study did not evaluate the relationship among the different indicators, future studies are recommended to explore their cause-and-effect interrelationship or to measure the consistent theoretical causal model among the indicators using methods such as fuzzy structural equation modelling or fuzzy decision-making trials and evaluation laboratory methods.

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