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Original citation & hyperlink:
Sustainable supply chain management towards disruption and organizational ambidexterity: A data driven analysis', Sustainable Production and Consumption, vol. 26, pp. 373-410.
https://dx.doi.org/10.1016/j.spc.2020.09.017

DOI 10.1016/j.spc.2020.09.017
ISSN 2352-5509

Publisher: Elsevier

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Abstract:

Balancing sustainability and disruption of supply chains requires organizational ambidexterity. Sustainable supply chains prioritize efficiency and economies of scale and may not have sufficient redundancy to withstand disruptive events. There is a developing body of literature that attempts to reconcile these two aspects. This study gives a data-driven literature review of sustainable supply chain management trends toward ambidexterity and disruption. The critical review reveals temporal trends and geographic distribution of literature. A hybrid of data-driven analysis approach based on content and bibliometric analyses, fuzzy Delphi method, entropy weight method, and fuzzy decision-making trial and evaluation laboratory is used on 273 keywords and 22 indicators obtained based on the experts' evaluation. The most important indicators are identified as supply chain agility, supply chain coordination, supply chain finance, supply chain flexibility, supply chain resilience, and sustainability. The regions show different tendencies compared with others. Asia and Oceania, Latin America and the Caribbean, and Africa are the regions needs improvement, while Europe and North America show distinct apprehensions on supply chain network design. The main contribution of this review is the identification of the knowledge frontier, which then leads to a discussion of prospects for future studies and practical industry implementation.

Keywords: Sustainable supply chain management, disruption, ambidexterity, data driven, content analysis, fuzzy Delphi method, entropy weight method, fuzzy decision-making trial and evaluation laboratory

Sustainable supply chain management towards disruption and organizational ambidexterity: a data driven analysis

List of acronyms

Sustainable supply chain management	SSCM
Supply chain	SC
Triple bottom line	TBL
Fuzzy Delphi method	FDM
Entropy weight method	EWM
Decision-making trial and evaluation laboratory	DEMATEL
Triangular fuzzy numbers	TFNs
Supply chain network design	SCND

1. Introduction

Sustainable supply chain management (SSCM) refers to manage the materials, information and capital flow, as well as collaboration and cooperation among the supply chain (SC) partners, deriving from stakeholders and customers, while implementing all sustainable development goals imitative from the triple bottom line (TBL) as economic, social, and environmental dimensions (Seuring and Muller, 2008). Over decades, the exploratory evolution on sustainability has followed by an augmented understanding on the wide-ranging and varied literature of the SSCM (Ansari and Kant, 2017; Rajeev et al., 2017; Brandenburg et al., 2014). However, the complexity of the dynamic global business environment has led to vulnerability to various SC risks (Munir et al, 2020). Significant study effort has been put into planning integrated systems that are able to withstand, respond to, recover from, and adapt to risks (Linkov et al., 2018).

SC disruptions are undesired and unexpected events; examples include natural disasters, industrial accidents, technological shifts, and political events (Braunscheidel and Suresh, 2009). Munir et al. (2020) stated that companies frequently encounter disruptions, which cause distress in entire SCs. Gölgeci & Kuivalainen (2020) point out that in the modern global market, disruptions are becoming an important priority due to their role in threatening the long-term survival of firms; this trend is displacing conventional firm-centric management predicated on a stable business environment. The consequences of such disruptions can be grave if not addressed promptly (Pettit et al., 2013; Pettit et al., 2019). As a result, how firms manage SC disruptions has become a critical issue for both academics and practitioners (Azadegan et al., 2019; Nooraie et al., 2019). The role of organizational ambidexterity has recently been recognized as very important for enabling firms to balance disruption impacts with other factors (Ivanov et al., 2014; Lee and Rha, 2016; Ojha et al., 2018). For example, the current COVID-19 crisis has highlighted the need to reconfigure modern supply chains to survive (Ivanov et al., 2020).

The concept of ambidexterity spans both exploration and exploitation to achieve long-term SC sustainability (O'Reilly and Tushman, 2011; Yang et al., 2014). Previous studies have recognized that SC ambidexterity should be included in operations management (Blome et al., 2013; Aslam et al., 2018). Yet, the association between disruption and SSCM ambidexterity has not been fully addressed. The current SC is insufficient to gain the benefits from SC ambidexterity and the compromises of resolving these problems are rare in the literature (Wamba et al, 2020). Studies on disruption and ambidexterity beyond the SSCM is specifically limited consequences practically worse if disruptions are informed (Lee and Rha,2016; Chowdhury & Quaddus, 2017). A comprehensive integrated assessment is urgent to extant the literature, this study offers a data-driven literature review that exemplifies a clear overall depiction of SSCM toward disruption and ambidexterity so that reveals hindering enhancement attributes.

Chen et al. (2019) stated that the positive effects of the cluster function effectively in the aftermath of disasters were able to address urgent orders rapidly and to minimize loss based on geographical proximity explanation. Dixit et al. (2020) state the SSCM network get influences by catastrophes arising due to the facilities location, scenery, geographical region, climatic circumstances, political situations. With an extensive geographic allocation of SC entities, an individual disruptive event may not eftect the whole network at a time or with the same scale (Hu and Kostamis, 2015; Kamalahmadi and Parast, 2016). However, the interlinked of SC partners is associated with the SC disruption risk and consequence a series of disruptions, which are threatening the global SSCM practices. For instance, the floods in Thailand, and earthquake and tsunami in Japan in 2011 showed an aggravated of global SC disruption (Kauppi et al., 2016; Shekarian et al., 2020). Recently, firms as Hyundai deferred its manufacture in South Korea; and Ford, Nissan, and Tesla shut down their factories; a drop in Apple products demand as results of the disruption caused by the Covid-19 outbreak in China are reported from February 2020 (Essuman et al,, 2020). Factory closures and drastic drops in product demand have led to major SC problems for many firms throughout the world (Yu and Aviso, 2020).

SC disruptions have highlighted the importance of post-disruption management from both research and practice standpoints. The identification of relevant factors for mitigating risk and ensure the survivability is a priority area. Laine and Galkina (2017) studied the effect of trade sanctions on the capability of import- or export-dependent firms to respond to major disruptions. Jajja et al. (2018) and Weijiao et al. (2018) investigated the effects of resource abundance, regulatory environment, and social institutions on the ability to cope with disruptive periods. Shah et al. (2020) related SC variables with research and development activities, manufacturing processes, and business connections, and compared firms in North America and Europe with those in

South America and Asia. The importance of regional effects was found to be significant. Thus, if firms intend to expand their SCs to other regions, they need to consider the potential impacts of disruptions on their performance (Parast, 2020).

Global SCs are characterized by complexity due to the presence of different players operating under diverse conditions in different countries and regions; such complexity poses formidable challenges to SC sustainability (Koberg and Longoni, 2019). Therefore, it is essential to scrutinize the regional aspects, aside from an overall review of the global literature. A systematic review is needed to classify state-of-the-art SSCM work and identify new directions and potential opportunities. This paper has the following objectives:

- To provide a survey the literature on SSCM trends towards disruption and ambidexterity
- To determine based on the data-driven indicators for future research
- To identify the challenges and knowledge gaps specific to geographic regions

This study contributes the following: (1) identification of the fundamental SSCM knowledge frontier, (2) provision of valuable future directions via data-driven analysis of the existing literature, and (3) assessment of global state and regional variations of SSCM literature. Since current SC are vulnerable to disruptions, there is a need to enhance sustainability to ensure future competitive advantage (Ivanov and Dolgui, 2019). This study covers both quantitative and qualitative approaches. A hybrid method based on content and bibliometric analyses, the fuzzy Delphi method (FDM), the entropy weight method (EWM) and fuzzy decision-making trial and evaluation laboratory (DEMATEL) is used. Content and bibliometric analyses is to identify the SSCM indicators based on publications data in the Scopus database (Gao et al., 2020; Shukla et al., 2019). FDM is applied to identify valid indicators from the experts' linguistic perception (Bui et al., 2020). EWM is used to find the indicators' weights to determine regional performance (Tseng, 2017). Fuzzy DEMATEL is used to identify the important indicators from human linguistic preferences for future study (Tseng et al., 2018).

The rest of this paper is organized as follows. The next section reviews the proposed methodology. The results of the analysis are presented in the third section. Then, the fourth section discusses the literature trends, and future challenges. Variations in regional trends are included. Then conclusions and suggestions for future work are given.

2. Literature review

The SC ambidexterity has attracted considerable interest in organizational theory (Turner et al., 2013; Stettner and Lavie, 2014; Wamba et al., 2020). The concept refers to firm's efforts to refine/extend its existing resources and to develop new SC competencies and yield performance benefits, especially for large manufacturing firms (Kristal et al., 2010; Aoki and Wilhelm, 2017; Partanen et al.,2020). Kristal et al. (2010) proposed that SC ambidexterity should be based on the implementation practices exploiting existing or new knowledge. Rojo et al. (2016) argued that the concept helps firms achieve flexibility, and enhanced performance. Aslam et al. (2018) stated that SC ambidexterity requires firms to be both agile in responding to short-term changes, as well as highly efficient in the long term. Organizational ambidexterity uses existing capabilities and strategic information flow to discover new opportunities (Partanen et al.,2020). Thus, there is consensus among researchers that ambidexterity entails sustaining firm competitive advantage considering both present and future performance.

Studies have measured the ambidexterity (Junni et al., 2013; Salvador et al., 2014; Zhao et al., 2021; Syed et al., 2020). Chandrasekaran et al. (2012) reported that both decision risk and alignment capabilities imitate ambidexterity proficiency at the firm level. Salvador et al. (2014) found product configuration ambidexterity influences the industrial equipment manufacturing through sales responsiveness and operating cost. Venugopal et al. (2020) revealed organizational ambidexterity is considerably affected by the top management team behavioral integration and their innovation practical choices. Syed et el. (2020) resolved the information technology ambidexterity inconsistencies and proposed that firms control these inconsistencies to develop their ambidexterity capability. Zhao et al. (2021) based on social exchange theory and transaction cost to inspect the second-order social capital impacts on the green innovation, aside from the role of governance ambidexterity. However, empirical ambidexterity study is still scarce, especially at the SC level. The SC resources require better utilization, while studies on the necessary capabilities to develop competency ambidexterity is limited (Hodgkinson et al., 2014; Turner et al., 2013, 2015; Sahi et al., 2020).

2.1. Organizational ambidexterity exploration and exploitation

The literature conceptualizes the ambidexterity into two perspectives, combined and balanced of exploitation and exploration (Cao et al., 2009; He and Wong, 2004). Patel et al. (2012) defined organizational ambidexterity as an operational synchronized component pursuit by exploration and exploitation. Particularly, exploitation objectives to enhance the existing materials or technologies, while the exploration is to collect and diverse new information and knowledge to systematized organizations (Guan and Liu, 2016; Lavie et al., 2010; Phelps, 2010; Yan and Guan, 2018). The researchers have designedly preferred to assess the combined effect of exploration and exploitation on firm performance (Uotila et al., 2009; Gualandris et al., 2018; Bravo et al., 2018). Sahi et al. (2020) measure the strategic orientation effects, such as market and business tactical positionings, on operational exploitational and explorational ambidexterity for improving business performance. The study found that small and medium firms' entrepreneurial and market orientations has greater prominence on explorative operational activities, and exploitative operational activities has high impacts on entrepreneurial orientation. Gomes et al. (2020) studied how ambidextrously exploitational and explorational quality management supports to production environmental sustainability development. The study offers evidence to quality management ambidexterity, the quality exploitation and exploration synchronized practices, is a vital environmentally sustainable production element to improve organizational ambidexterity capabilities and achieve sustainability goals.

In contrast, firms can develop the ambidexterity by attaining and sustaining a balance between (1) exploitation, such as exploit value from resources, existing markets, and competency, to guarantee contemporary practicality; and (2) exploration, such as explore new products, markets, and opportunities, to warrant future feasibility (Guan and Liu, 2016;Khan et al., 2019; Phelps, 2010; Sahi et al., 2020; Wang et al., 2014; Yan and Guan, 2018). Balanced ambidexterity is pursued in an impartial means. Kristal et al. (2010) measured the exploitation and exploration complementary and supported a balance between two with constructive possessions on business performance. However, it is argued there is pressure between exploitation and exploration valuable ground found in environmental sustainability since ambidextrous operations require cross-border decision strategies to deal with the external environment changes with the internal resources and capabilities supports. Gualandris et al. (2018) claimed small firms are better with enhanced exploration rather than balancing the two dimensions in rapidly changing SC environment with technologies, policies, and market requirements. Zhao et al. (2021) argued that exploratory innovation not only reserves and enriches the existing knowledge, but also generates new materials or technologies compared with the exploitative innovation. The resources switching from exploitation to exploration and reverse might threaten the firms' operational functions (Sahi et al., 2020). It is critical for researchers to scrutinize the antecedent's effects and of different ambidexterity outcomes. Understanding managerial perspective on how to control exploration and exploitation-based to optimize profitability is remained as an uncertain milieu and limiting resources utilization. The limited resources, skills and capabilities, the pressure that between exploration and exploitation has established a challenge to proper balance the two dimensions for better SSCM performance.

2.2. Supply chain disruption and organizational ambidexterity towards sustainability

Sustainable production and consumption complex transformations is requiring firms to instantaneously push them to change from traditional operation to incrementally increasing to a more disruptive adaptation approach (Gualandris et al., 2018). The organizational ambidexterity is argued to be capable for firms to efficiently control current business demands while fundamentally being adaptive to changes to develop the sustainable SC systems (Hajli et al., 2020; Gomes et al., 2020; Parast, 2020; Syed et al., 2020; Yu et al., 2019). Firms must decide interpreting with most beneficial relationships to recovery in the face of disruption and difficulty. Having strategic inter-sectional and inter-organizational bonds within supply chains is important (Capaldo, 2007; Gölgeci and Kuivalainen, 2020).

Prior studies have compared the ambidexterity effects on varied measures such as firm performance, supply chain competence, supplier product innovation, cooperative innovation, helping firms to create advantageous environments (Cao et al., 2009; Gualandris et al., 2018; Bravo et al., 2018; Wang et al., 2018; Crescenzi and Gagliardi, 2018). Ponis and Koronis (2012) examined the SC network proactive plan and design ability to predict unexpected disruptive events, and adaptively respond to, while preserving the SC structure and function, and exceeding to a post operations-robust stage. Alamerew and Brissaud (2020) explored the system dynamics using TBL aspects from a close-loop SC to grants a complex systemic model of reverse logistics to recover end-of-life products based on cost, revenue, regulatory, and strategic decisions; and proposed that researchers, practitioners, policy makers need to improve their knowledge sharing among the main CE pillars and the strengthen the interaction among numerous decision factors. Essuman et al. (2020) developed the operational resilience notion and investigated its effects on operational efficiency under different operational disruptive situations and found both disruption absorption and recoverability have positive relationship to operational efficiency. Fattahi et al. (2020) provides a stochastic optimization of disruption drives on SC network design to measures the expected SC's surplus cost with new resilience metric that quickly and effectively forms the SC back to its original or even more desirable state after the disruption and during its recovery phase. Shekarian et al. (2020) determined the flexibility and agility impacts on the relationship between three objective functions including risk, responsiveness, and cost of new and seasonal products on of disruptions mitigation.

Munir et al. (2020) built upon the information process and explored the association between SC integration and risk management to improve operational performance during unexpected disruptions and uncertain changing of business environments. The study suggested the internal, SC integration positively effects the risk management, while the internal integration impacts is moderately mediated by supplier and customer integration and fully mediates the operational performance and SC association. Hajli et al. (2020) explored the inter-relationships among data analysis instruments and its effectiveness to customer agility and new product success. The study provided significant theoretical contributions by demonstrating the role of big-data aggregation tools, big-data analytics, organizational negligent, customer agility, and environmental instability in new product success. Parast (2020) examined firm's research-and-development investment effects on easing SC disruptions using four disruption risks categories including process, supply, demand, and environmental. The study found the investment possibly improves the firm's resilience capability and significantly reduce the process, supply, demand, and environmental disruption effects on initial firm and SC performance.

Still, there are only few studies have explored the ambidexterity dimensions impact on firm financial performance (Enke and Bausch, 2013; Kerry and DeSimone, 2019; Venugopal et al., 2020). Researchers have scrutinized ventured ambidexterity measures but ignores with the mutual reinforced indicators and fail to discover their influences on financial performances (Kerry & DeSimone, 2019). Besides, inactive procedures, such as overloaded with social capital burdens, can limit the information processing, and over-commitment to conventional relationships resulting in structural modifications delay and disrupt the social capital positive use that affected and harm disruptions resistant (Pillai et al., 2017). Even though, the literature has revealed the mixed findings between firm performance and different SC disruption scenarios and organizational ambidexterity association (Devaraj et al., 2007; Koufteros et al., 2005); there are limited studies investigated the role of ambidexterity in the sustainable production systems development effects an organization's performance measurement, and also on the circumstances that firms benefits from (Gualandris et al., 2018; Bravo et al., 2018). Despite the prior studies has observed the detail ambidexterity concurrences and offered substitute to the SC progressive clarifications, studies scrutinizing the firm's balanced ambidexterity performance are underdeveloped such as practicing SC management required inputs to avoid redundancy in SC network structure. A systematic review is needed to organize state-of-the-art SSCM work and detect new directions and potential opportunities in the aforementioned studies. The SSCM towards disruption and organizational ambidexterity main indicators are determine, their description and related studies are addressed (as in Table 3).

3. Data collection and methodology

The proposed analysis steps are presented in this section, offering a clear explanation of the data collection process, content and bibliometric analyses, FDM, EWM, and FDEMATEL.

3.1. Proposed method and analysis steps

In the literature, Gómez-Luciano et al. (2018) used value chain methodology to review the theoretical foundation and literature of the supply markets and globalization linkages. Cicculllo et al. (2018) apply the meta-synthesis to summarize and cumulate the integration of agile, lean, and SSCM models toward the environmental and social sustainability for literature review. Bastas and Liyanage (2018) conducted a thematic analysis to study the sustainable SC quality management state-of-the-art by integrating intra-organizational emphasis inter-organizational assessment. However, those methods are lacking empirical evidence support making the result may become selective bias and the ambiguity from inferred literature and authors' intention (Ciccullo et al., 2018; Gómez-Luciano et al., 2018). Considering the literature as a big-data source, there are lack of big-data assessment on multi-attribute decision making to enrich the SSCM (Tseng et al., 2019). an integral data-driven solution must be addressed to accomplish higher efficiency and effectiveness (Tseng et al., 2018b). Prior studies have discovered the of big data components for building the SSCM (Akter et al., 2016; Zhan and Tan, 2020). Maroufkhani et al., (2020) proposed a data-driven analysis to obtain the technological-organizational-environmental paradigm to implement the lessening resource utilization and emission reduction solutions in SSCM systems. Majeed et al. (2021) developed a modeling structure by uniting big data analytics to additive manufacturing, and sustainable smart manufacturing technologies which is advantageous to the additive manufacturing initiatives.

Due to the uncertainty and complexity of SSCM, this study proposed a hybrid multi-attribute decision making approach including data-driven analysis, the FDM, the EWM and FDEMATEL. The data-driven analysis combines the content analysis and bibliometric analysis to employing data and categorize the review process. The FDM is used to refine and validate the indicators by computing their perception levels from the experts' linguistic references (Tseng and Bui, 2017). The EWM is used to convert the indicator occurrence information into comparable weights to determine the indicator's performance among regions (Tseng, 2017). The Fuzzy DEMATEL method is used to identify human perceptions of linguistic preferences and the important indicators that require urgent focus for further study to improve SSCM (Tseng et al., 2018a). This study offers a literature review, identifies indicators for the improvement of future studies and provides differences in state-of-the-art regional SSCM toward disruption and ambidexterity. A committee of 30 experts was approached to guarantee the reliability of the analytical procedures. The committee was gathered among scholars and professionals with at least 8 years of experience and studying working in SSCM, including 12 experts from academia, 8 experts from government offices and non-government organizations, and 10 experts from the practical field (show in Appendix A).

The analysis steps are proposed as follows:

(1) A feasible search term is identified for deductive coding - content analysis to collect the publication information from the Scopus database.
(2) Bibliographic analysis is conducted by adopting VOSviewer software to identify the SSCM indicators in disruption and ambidexterity, nations coupling and regional categorize are generated from the database.
(3) The experts' evaluation on proposed indicators is conducted using the questionnaire. The FDM is used to screen out the invalid indicators.
(4) The indicators' frequency is generated by conducting the inductive coding - content analysis, and the EWM is adopted to translate the indicators' entropy into comparable scales to specify the regional comparison.
(5) The important indicators for each region and the overall scenario are identified using the fuzzy DEMATEL to scrutinize the future study gaps.

The analysis processes are presented in Figure 1.

INSERT Figure 1 HERE - Analytical procedure

3.2. Data collection

Prior studies have approached a literature review on SSCM by employing data from Dialnet Plus, Arts and Humanities Citation Index, JSTOR Archival Journals, Proquest, PLoS, ScienceDirect, Business SourcePremier, Emerald Journals, Science Citation Index, and Social Sciences Citation Index (Koberg and Longoni, 2019; Rebs et al., 2019). However, these databases conceal a smaller group of publications. This study engages to the Scopus database due to its broader publication array and more related bibliometric outline (Jin et al., 2018). The database offers wide coverage of peer-reviewed academic literature, such as social sciences, engineering, and scientific journals, books and conference proceedings; including title, abstract, keywords, author, author affiliation, publication time, citation record, and country identifications.

3.3. Content analysis

Content analysis, as a tool to study documents and communication objects based on systematic reading or observation of texts or artifact (Hodder, 1994), is used to check for regional consistency of independent coding in counting indicator frequencies of each specific region by searching in the regional data generated from the Scopus database. The technique offers reproducible and laborious literature reviews to investigate the documents distribution (Seuring and Gold, 2012). The method is to intensely define the features of the full-text articles through compacting sizable of texts and words into predefined and much smaller categories (Horne et al., 2020; Vaismoradi et al., 2013). Bhatt et al (2020) has apply bibliometrics and content analysis for developing the intellectual structure of sustainable manufacturing literature. Thomé et al. (2020) used the method to determine and illustrate the co-occurrence conceptual framework of food SCs and short food SCs, at odds with the current divergence of the literature approaches. Based on text mining to classify constructive information in textual data (Zanjirchi et al., 2019), content analysis is an essential step to assess a high volume of data in a structured and systematic approach by precisely capture relevant information to identify valuable topics, methods and themes with manual approaches(Gao et al., 2020; Kazemi et al., 2019).

There are two types of content analysis coding: inductive and deductive coding (Seuring and Gold, 2012). The deductive type conducts the coding before the data evaluation and determine the analytic categories centering on the study proposed. The inductive coding is naturally obtained the analytic categories from the data during the review process. This study first using the deductive method to predefined search terms used to drive SSCM literature on disruption and ambidexterity from Scopus databased. Since the great disruption in 2008 creates real challenges on focused execution, there has been growing body of SSCM literature on disruption and ambidexterity. The search boundary was established to publications within 11 years, from 2008 to 2020 (searching date is May 4th, 2020) and limited to English-language articles and reviews. The search terms used were “("supply chain") and ("ambidexterity" or "disrupt*" or "crisis" or "crises" or "chaos" or "interrupt*")” generating in titles, abstracts, or keywords. Following, the inductive type is applied by using bibliometric analysis to identify by code-wording from literature review.

3.4. Bibliometric analysis

The bibliometric analysis is a quantitative method to accomplish a visual illustration of accumulative literature by providing scientific mapping and other repetitions (Zupic and Cater, 2015). This study performs a bibliometric analysis using VOSviewer version 1.6.11, open source software to scientifically categorize documents with similar connotation into the same cluster to define their relationships (Eck and Waltman, 2018). In the SC context, Feng et al. (2017) used this software to acquire a bibliometric literature review of corporate social responsibility. Wang et al. (2019) used VOSviewer to reveal gaps and opportunities for future investigation in off-site construction. These papers illustrate the usefulness of VOSviewer and is the basis for its selection in this review.

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3.5. Fuzzy Delphi method

This study combines the fuzzy set theory and the Delphi method to help address the lack of expert references and to improve questionnaire quality (Ishikawa et al. 1993). It is used to refine the valid indicators based on experts’ linguistic perceptions (Bui et al., 2020). The method can transform their fuzzy assessment into fuzzy numbers efficiently.

In the analytical process, assume that there are n experts and m indicators. Expert a has to evaluate the prominence of indicator b as $j = (x_{ab}; y_{ab}; z_{ab})$, $a = 1,2,3, \dots, n$; $b = 1,2,3, \dots, m$, where the j_b weight of b denotes as $j_b = (x_b; y_b; z_b)$ 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 perception is translated into triangular fuzzy numbers (TFNs), as presented in Table 1.

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

Then, convex value D_b is determined by:

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

Where the u_b, l_b are calculated using a δ cut as:

$$u_b = z_b - \delta(z_b - y_b),$$
$$l_b = x_b - \delta(y_b - yx_b), b = 1,2,3, \dots, m \quad (2)$$

This δ value can be modified from 0 to 1 towards positive or negative perceptions. The value is usually designated as 0.5 to discourse the regular situation.

The threshold to refine 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 detached.

In this study, the FDM process is executed in 2 rounds. A face-to-face interview with the expert committee is held to refine the keywords as proposed indicators for analysis. The round 1 is aims remove the needless attributes by conforming expert judgments and round 2 allows experts to amend their judgment based on simplify attribute set from round 1 (Lee et al., 2018). The process allows the experts to clarify their selections by rapidly accomplishing conjunction in revising their judgement on validating the proposed attribute set (Bui et al., 2020).

3.6. Entropy weighted method

The EWM is used to determine geographical variations in SSCM research.

The inductive content analysis is used alleviate the use of EWM on coding indicators' frequencies. The search term for each regions is predefined to generate the regional data (see Appendix B).For instance, the search term to generate the regional data of Latin America and Caribbean is "TITLE-ABS-KEY ("Brazil" or "Mexico" or "Chile" or "Argentina" or "Colombia" or "Peru" or "Costa Rica" or "El Salvador" or "Puerto Rico")". The frequency of each keyword for each region is then generated by using the keywork search in the regional databased as the input for EWM. The coding is tracked in comparable Excel file to avoid duplicating the computation activities and enhance the reliability of the result.

The indicator frequency weight τ is calculated with ε is identified with a coefficient value between zero and one. The value is generally set in 0.5 reflecting the common case, with:

$$\tau_{0,i} = \sum_{m=1}^{n} w_m \varepsilon_{0,i}(m) \text{ for } i = 1,2, \dots m \quad (3)$$

where the weight $(w_m, \sum w_m = 1)$ for each distinguishing indicator is calculated using the entropy method.

The entropy method quantifies an incoherent arrangement using weight measurement. An entropy weight method reflects the utility value of an indicator and given more reliable indicator weights are when revising the incomplete information (Tseng et al., 2013). The method is a quantity disorganizing system applied in weight measurement showing that an indicator with a large entropy mean, and a great diversity of responses makes the indicator have a more substantial impact on the system reaction (Wen et al., 1998). The higher entropy weight an indicator has, the greater diversity responses has experienced, and the more substantial effect as the indicator reacts to the structure (Tseng, 2017). The method encompasses function $f_i: [0,1] \rightarrow [0,1]$ and validates three constraints, (1) $f_i(0) = 0$, (2) $f_i(x) = f_i(1-x)$, and (3) $f_i(x)$, to extend the range of $x \in (0, 0.5)$. The largest value of this function is at $x = 0.5$, and the value $(\partial^{0.5} - 1)$ puts the result in the range $[0,1]$. The entropy weighted computational processes are as follows:

Coefficient arrangements for each indicator are calculated as follows:

$$C_j = \sum_{i=1}^{n} \varepsilon_i(j) \quad (4)$$

where w_e refers to indicator frequency determined by the content analysis.

The entropy weight of each indicator is generated as:

$$e_j = k \sum_{j=1}^{n} w_e \left(\frac{\varepsilon_i(j)}{e_j}\right) \quad (5)$$

The total entropy values are computed following:

$$E = \sum_{j=1}^{p} e_j \quad (6)$$

Each indicator's weighted value is determined:

$$w_j = \frac{\frac{1}{p} - E(1-e_j)}{\sum_{j=1}^{p} 1/p - E(1-e_j)}, j = 1,2,3, \dots, p \quad (7)$$

3.7. Fuzzy decision-making trial and evaluation laboratory

Fuzzy set theory is used to translate expert's linguistic perceptions into quantitative form, while DEMATEL is used to map causality relationships of concepts (Tseng et al., 2018). Tseng et al. (2018) used the fuzzy DEMATEL to handle complexity, so that examine the attributes distribution based on the identification of driving and dependent powers and offer visual analysis. Bui et al. (2020) employed the method to address human linguistic preferences and analyze the complicated interrelationships among the attributes. Tsai et al. (2020) used the method to convert the qualitative information into crisp values for visual analysis, and the causal relationships among attributes are examined. Thus, this study uses Fuzzy DEMATEL to investigate the attributes distribution based on the of driving and dependent powers identification and offer visual analysis under uncertainty.

Fuzzy DEMATEL converts linguistic knowledge into TFNs and then defuzzifies them into crisp values. The fuzzy membership functions $\tilde{e}_{ij}^{k} = (\tilde{e}_{1ij}^{k}, \tilde{e}_{2ij}^{k}, \tilde{e}_{3ij}^{k})$ are used to compute the total weighted values. Left and right values are generated from minimum and maximum fuzzy numbers. The crisp values are afterward obtained into a total direct relation matrix that is used to draw an inter-correlation diagram to visual the analytical results. A set of indicators is addressed as $F = \{f1, f2, f3, \cdots, fn\}$, and accurate pairwise evaluation is then used to create the mathematical relation.

In particular, this study obtained and accumulated crisp values using linguistic scales from VL (very low influence) to VHI (very high influence) (presented in Table 2). If there are k experts involved in the evaluation process, $\tilde{e}_{ij}^{k}$ specifies the fuzzy weight of the i^{th} indicator's effect on attribute j^{th} evaluated by expert k^{th}.

(INSERT Table 2 here- TFN linguistic scale for FDEMATEL)

The fuzzy numbers are abridged as:

$$F = \left(f\tilde{e}_{1ij}^{k}, f\tilde{e}_{2ij}^{k}, f\tilde{e}_{3ij}^{k}\right) = \left[\frac{(e_{1ij}^{k} - mine_{1ij}^{k})}{\Delta}, \frac{(e_{2ij}^{k} - mine_{2ij}^{k})}{\Delta}, \frac{(e_{3ij}^{k} - mine_{3ij}^{k})}{\Delta}\right] \quad (8)$$

where Δ= $maxe_{3ij}^{k} - mine$

The left (lv) and right (rv) normalized values are compute using:

$$\left(lv_{ij}^{n}, rv_{ij}^{n}\right) = \left[\frac{(fe_{2ij}^{k}}{\left(1 + fe_{2ij}^{k} - fe_{1ij}^{k}\right)}, \frac{fe_{3ij}^{k}}{\left(1 + fe_{3ij}^{k} - fe_{2ij}^{k}\right)}\right] \quad (9)$$

The total normalized crisp values (cv) are expressed as:

$$cv_{ij}^{k} = \frac{[lv_{ij}^{k}\left(1 - lv_{ij}^{k}\right) + (rv_{ij}^{k})^{2}]}{(1 - lv_{ij}^{k} + rv_{ij}^{k})} \quad (10)$$

The synthetic values' symbolization to accumulate individual insight from k experts are then accomplished by:

$$\tilde{e}_{ij}^{k} = \frac{(cv_{ij}^{1} + cv_{ij}^{2} + cv_{ij}^{3} + \cdots + cv_{ij}^{3})}{k} \quad (11)$$

Pairwise comparison is employed to procure a direct relation (IM) $n \times n$ initial matrix, where $\tilde{e}_{ij}^{k}$ refers to the influence level of indicator i on indicator j, qualified as $IM = [\tilde{e}_{ij}^{k}]_{n \times n}$.

The normalized direct relation matrix (U) is formed as:

$$U = \tau \otimes IM$$

$$\tau = \frac{1}{\max\limits_{1 \le i \le k} \sum_{j=1}^{k} \tilde{e}_{ij}^{k}} \quad (12)$$

The inter-correlation matrix (W) is obtained from the normalized direct relation matrix using:

$$W = U(I - U)^{-1} \quad (13)$$

where W is $[w_{ij}]_{n \times n}$ $i, j = 1,2, \cdots n$

The values of the driving power (α) and dependence power (β) are assimilated from summation of the row and column values in the interrelationship matrix using:

$$\alpha = [\textstyle\sum_{i-1}^{n} w_{ij}]_{n \times n} = [w_{i}]_{n \times 1} \quad (14)$$

$$\beta = [\textstyle\sum_{j-1}^{n} w_{ij}]_{n \times n} = [w_{j}]_{1 \times n} \quad (15)$$

The indicators are located in an inter-correlation diagram originated from $[(\alpha + \beta), (\alpha - \beta)]$, which in turn presents horizontal and vertical axes. The indicators are assembled into cause and affect groups based on whether the $(\alpha - \beta)$ values are positive or negative. $(\alpha + \beta)$ displays the importance of indicators: the higher $(\alpha + \beta)$ value an indicator has, the more important it is. This study uses the average value of $(\alpha + \beta)$ to identify the most important causal indicators, which then necessitate supplementary emphasis.

4. Result

This section reports SSCM data-driven coupling and FDM results. The EWM results is employed to clarify the regional differences, and top indicators from the FDEMATEL analysis is determined for further discussion.

4.1. Content and bibliometric analyses

From the content analysis, the search of the Scopus database shows that there are 2,402 publications in total. Author keywords distribution is illustrated in the co-occurrence bibliographic coupling form via VOSviewer, listing 273 keywords which occur at least 5 times (see Appendix C). Furthermore, there are 91 countries/territories verified, with 1 is the minimum documents quantity for a country. Based on the United Nations (2019), the countries/territories are classified into five geographical regions, including Asia and Oceania, Europe, North America, Latin America and the Caribbean, and Africa (shown in Appendix F).

4.2. Fuzzy Delphi method

A face-to-face interview between the expert committee was held, identifying 155 indicators from the 273 author keywords for the FDM phase. The set of indicators are evaluated by the experts and the linguistic perceptions are transformed into conforming TFNs (in Table 1). There are 105 indicators are eliminated from the proposed attribute with a threshold 0.290 remaining 50 indicators for the FDM-round 2 (addressed in Appendix G). In the round 2, a total of 22 indicators, whose $\boldsymbol{D_b}$ value above 0.306, are refined (addressed in Appendix H), resulting final list of indicators as the input for the next analysis stage. The indicator description and related studies are addressed using the content analysis are addressed (shown in Table 3).

INSERT Table 3 HERE – Final List of FDM indicators result

4.3. Entropy weighted method

The EWM quantifies the information content of each indicator. Table 4 provides the indicators' entropy weights in each of each region, as well asthe overall value. The higher the entropy assessment is, the smaller the weight is, and more information is delivered (He et al., 2016). The weights are averaged to identify the indicator information level in each region. The indicator needs enhancement if the weight is larger than the average (Table 5). The results show that publications from North America and Europe provide the highest information content in the context of SSCM disruption and organizational ambidexterity. On the other hand. Africa, and Latin America and the Caribbean have the lowest scores. Although Asia and Oceania have the highest productivity based on number of publications, the information content of these outputs still leaves room for improvement.

INSERT Table 4 HERE - Regional entropy weights

INSERT Table 5 HERE - Region Entropy weight comparison.

4.4. Fuzzy decision-making trial and evaluation laboratory

From the FDM results, the committee evaluated the indicators' inter-correlation using the provided linguistic scales as in Table 2. The fuzzy direct relation matrix and the defuzzification are converted into the crisp value to generate the initial direction matrix using average technique (see Table 6). The total inter-correlation matrix is created (see Table 7), representing the inter-correlation among the indicators (shown in Table 8). Figure 2 illustrates the inter-correlation diagram of the regions based on $(\alpha + \beta)$ and $(\alpha - \beta)$ cuts. The average value of $(\alpha + \beta)$ is used to classify the top important causing indicators that need to be concentrated.

The differences between regions are reported. Specifically, the important indicators for Asia and Oceania consist of SC agility (I8), SC coordination (I11), SC finance (I14), SC flexibility (I15), SC resilience (I18), uncertainty (I22). For European region, such important indicators are SC agility (I8), SC coordination (I11), SC finance (I14), SC flexibility (I15), supply chain network design (SCND) (I17), sustainability (I21). For North America regions, the important indicators SC agility (I8), SC coordination (I11), SC flexibility (I15), SCND (I17), SC resilience (I18), sustainability (I21). The Latin American and Caribbean focuses on SC agility (I8), SC finance (I14), SC flexibility (I15), sustainability (I21), uncertainty (I22). While SC coordination (I11), SC finance (I14), SC flexibility (I15), SC resilience (I18), sustainability (I22) are Africa regions' important indicators.

Overall, the top important indicators in this study are SC agility (I8), SC coordination (I11), SC finance (I14), SC flexibility (I15), SC resilience (I18), sustainability (I21), venerating to continuous responses in the system, which are considered as critical study trends to approach SSCM toward disruption and ambidexterity.

INSERT Table 6 HERE – Overall initial direction matrix

INSERT Table 7 HERE – Overall total inter-correlation matrix**)**

INSERT Table 8 HERE - Causal inter-correlation among indicators.**)**

INSERT Figure 2 HERE - Causal inter-correlation of indicators among regions**)**

5. Discussions

Future study trends and challenges and the implications for regional state-of-the-art SSCM in disruption and ambidexterity are discussed in this section.

5.1. Study trends and future challenges

This study has identified the top indicators of SSCM trends towards disruption resilience and organizational ambidexterity as follows: SC agility, SC coordination, SC finance, SC flexibility, SC resilience, sustainability. These indicators play an essential role in identifying future priorities.

5.1.1. Supply chain agility

The concept of SC agility shows an emergent compromise of emphasizing on firms' ability to quickly sense and respond to unplanned market fluctuations, such as reduce production cycle or total lead time, growth of invention customization level or customer service, changing in delivery, and responsiveness reliability toward market place (Alfalla-Luque et al., 2018; Blome et al., 2013; Eckstein et al., 2015; Lim et al., 2017). The indicator refers to the capability to deal with unexpected short-term, temporary changes as well as to rapidly acclimatize to those changes in SC and market environment (Aslam et al., 2018; Eckstein et al., 2015). It is essential to a firm's survivability through the capability to find opportunities in unforeseen circumstances (Kale et al., 2019). Agile firms can rapidly reconfigure and respond to changes in market demand, and thus improve the responsiveness of their SC (Shekarian et al, 2020).

SC agility has been expansively studied and allied to organizational performance, thus, increase sustainability outcomes. Prior studies have recognized that agile ability have positive effects on financial performance and operational measures (Eckstein et al., 2015; Tse et al., 2016). Information technology can be utilized help to optimize firm agility and profitability to establish sustainable SC practices (Yusuf et al., 2020). SC agility helps to cope with demand in the absence of capability to reduce unsustainable initiatives (Wu et al., 2016). However, the leading role of agility in promoting sustainability is not comprehensively understood. The potential indicators of social and environmental sustainability, as well as their interactive possessions have yet not been explored. Agility metrics require future integration into sustainability aspects. Data mining and analytics can be used to achieve competitive advantage through sustainable agility (Ciccullo et al., 2018; Chen et al., 2017, Kitchens et al., 2018). Implementing sustainability is difficult without knowledge of SC stakeholders' perspectives (Gunasekaran et al., 2019). Upstream and downstream collaboration is needed to ensure alignment of the goals of SC players (Gligor, 2014; Wu et al., 2017). However, there is still lack of empirical study examining the influence of SC agility on the sustainable performance of firms.

SSCM in the face of disruption risk has been the subject of growing research interest (Parast et al., 2019; Ho et al., 2015; Gligor et al., 2015). Interplay of the key factors to enhance agility performance within these disruption scenarios is still not fully understood. Firms depend on their SC to remain competitive and agile in a fluctuating environment (Battistella et al., 2017; Yang, 2014). Dynamic capabilities are needed to improve agility performance and reduce risk (Jajja et al., 2018). Use of facilities which can be put into use immediately after interruption is also important (Chen et al., 2019). Thus, executing agility into account of SC disruption and ambidexterity in crisis given the cross functions and decision makers to facilitate the entire itinerary of sustainable recovery. Considering SC agility as a firm's inter- and intra-ability for achieving timely response to market changes as well as to potential and actual disruptions is needed.

5.1.2. Supply chain coordination

Coordination and synchronization among SC partners is a significant issue in business (Hitt et al., 2016). The SC literately declares the effects of collaboration and integration between suppliers and customers as coordination for firms to improve the ability to successfully occupy with SC partners (Zhao et al., 2011; Munir et al., 2020). SC function braces up as operational processes requires coordination and cooperation within the organization and with external entities, including the connection to the customer (Ojha et al., 2018). Coordination facilitates and ensures the efficient and effective flow of information, material, other resources, and decision for maximizing production value, given that firms substantially enhance integrating performance and identify opportunities to achieve higher benefits (Chen et al., 2020a). However, greater coordination intensifies more complexity and negative impacts as unavoidable coincidences or even interrupt the SC (Munir et al., 2020). As the upstream usually espouses a conventional building capacity policy to circumvent the demand uncertainty risk, the downstream has to face a lack of supplies to satisfy the market demand, thereby reducing the total benefits of both manufacturer and buyers, consequently results in a poor performance (Li et al., 2020).

Disruption is caused by accidents such as organization breakdowns, natural disasters, or pandemics that constrain standard processes in SC, and incapable of synthesize internal and external coordination to support SC (Wong et al., 2019). SC risk arises from the disruption of materials, products, information, and financial flows which can disrupt firms' normal operations (Snediker et al., 2008; Munir et al., 2020). This remains as fundamental managerial challenge that affects the organizational performance (Gölgeci & Kuivalainen, 2020, Shekarian et al., 2020). This remains as fundamental managerial challenge that affects the organizations performance and implements appropriate coordination and collaboration strategies to manage their interorganizational relationships (Gölgeci & Kuivalainen, 2020, Shekarian et al., 2020). To maintain the SSCM, several coordination mechanisms are proposed to motivate the SC members. In SSCM, multiple coordination mechanisms have been proposed for SC players. Collaborative recovery capability based on the SC coordination mechanism was developed for disruption management by Matsuo (2015). The use of information processing for risk management was proposed to improve SC operational performance (Munir et al., 2020). The complications of transboundary linkages in global SC was analyzed by Velter et al. (2020). SC ambidexterity can be used to improve coordination efforts among multiple stakeholders.

However, the coordination itself requires extra efforts in sustainability innovation compared to traditional business model as successful alignment on both strategic and normative dimensions (Breuer and Lüdeke-Freund, 2017; Geissdoerfer et al., 2018). Strategic alignment with key SC partners needs to be spent more attentions to provide the insights of suppliers' capabilities, restrictions, and processes for effective forecasting and planning, designing products over operational management. While alignment between focal companies and stakeholders is deemed critical to solve such sustainablization difficulties. For instance, the misalignment in information system would distress the sustainability practices progress (Goni et al., 2017; Bocken et al., 2019; Freudenreich et al., 2019). The distinct motives of different firms can lead to tensions within the SC (Gölgeci et al., 2019).

There are existing gaps between organizations sustainability and the firm's cooperation strategies and capabilities between the external environment and operational processes (Amui et al.,2017; Heracleous & Werres, 2015). Firms need to remobilize and allocate their resources and capabilities to implement sustainability strategies as stakeholder requirements (Chowdhury et al., 2019). Study on how to handle obstacles of deficient information technology integration, inadequate collaboration, insufficient alliance is crucial (MacDonald and She, 2015; Wu et al., 2017). Supporting the social perceptions and behavioral intentions, trust, and communication protocols among the alignment connections to provide the necessary structural climate of effective coordination are required. Since prior studies have shown the complex relationship exists within the SC, salient network capabilities, collaborative proficiencies, and absorptive capacity are crucial to achieving competitive advantage (Adams et al., 2012; Kauppila, 2015; Partanen et al; 2020).

5.1.3. Supply chain finance

The SC finance toward the sustainability is described as financial mechanism offers such business transactions to minimize negative effects and generate more environmental, social, and economic values (triple bottom line - TBL) for the SC (Business for Social Responsibility, 2018). This is an approach for both up-and-downstream players, and those third-party financial service providers, to produce additional benefits through cooperate in monitoring, and developing the flow of financial resources within the SC (Hofmann, 2005). The indicator is recognized to reduce operational costs and create more profit for the SC members by improving financial performance and promote sustainability (Dye and Yang, 2015; Gong et al.,2018). In practices, adopting the SC finance is demonstrated to encourage the market exploitation and enhance financial performance, afterward improving competitive advantage (Li and Chen, 2019). Multiple organizational structures of purchasers collaborating with financial services providers for reverse factoring, inventory financing, dynamic discounting, and purchase order to provide liquidity suppliers is proposed (Caniato et al., 2016; Gelsomino et al., 2019). A partial credit guarantee assessment targeting in minimizing the risk from market failure by reducing financial loss are developed (Lu et al., 2019). However, there is limited in scope since the SCF is considered as a financing tool only (Liu et al., 2015a; Chakuu et al., 2019). This finance-oriented approaches normally concentrate on a narrow perception, and unable to deliver high quality solutions to SCF problems.

Disruptions can cause financial damage for related firms, leading to substantial financial lost and operational changing consequences that cost reputation and businesses status or even bankrupt (Bode and Wagner, 2015; Dabhilkar et al., 2016). These disastrous events are basically unforecastable due to limited cautionary and its impacts are difficult to predict until the events occur (Wong et al., 2019). Firms with higher market power likely to adore unchallenged leases, and any disruptions within the SC might threaten its maintenance ability. If suppliers involve financial suffering due to the credit crisis and struggle in fulfill market demands, they could suspend manufacture toward the SC and harm to downstream firms (Gonçalves et al., 2018). Therefore, a SC finance-oriented thought is that maintaining systematic payment term extensions against suppliers would result in upstream SC disruptions and causing negative prevarications (Wetzel & Hofmann, 2019). Investing limited resources into uncertain projects may intensify the costs, lowers success rates, and subsequently decreases firm performance (Song and Di Benedetto, 2008). Moreover, a strong alliance management capability is harmful for firms as they begin to favor interorganizational exploitation over the exploration, which leads to increased short-term financial performance but also decreases a firm's long-term growth (Kauppila, 2015; Partanen et al., 2020). Overall, the economic shocks are via financial markets making the SC finance become part of the problem of sustainability decline. This seriously hit on confidence of both suppliers, buyers, and intermediate financial institutions.

In contrast, empirical evidence shows that greater levels of disruption absorption and recoverability generate an enhanced competitive advantage and financial performance (Kwak et al., 2018; Wong et al., 2019; Yu et al., 2019). Though disruptions are unavoidable, firms that nurture a strong SC disruption positioning are able to accomplish higher financial benefits by enhancing the resiliency (Blackhurst et al., 2011; Hohenstein et al., 2015). The crisis is argued to provide an exclusive gap in the non-financial firms' behavior investigation, which mainly rely on the frame of financial sector (Garcia-Appendini and Montoriol-Garriga, 2013). SC finance sustainability also associates with the SC networks that the financial metrics have a close integration to technical operations, data and information exchange, and liquidity injections (Tseng et al., 2019). This progresses investors' confidence in future businesses since positive returns growth over operational risks such as logistics jeopardies and disruption capacity result in the stock market response towards the service providers is favorable (Lam et al., 2019).

the relationship between SC finance on SSCM towards disruption and ambidexterity in crisis is remain unclear and needs for wider and deeper investigation. The conflictions have shown that there is limited of study, which explained by fact that is a relatively new concept and has yet to attract more attention. The theories and practices of finance flow management SSCM are lagging behind the goods and information flow management studies (Wang et al, 2019). The goods flow along SC may be interrupted if the financial flow is not properly managed along the SC (Wuttke et al., 2013). The collaboration and coordination among SC partners in finance flows, such as advance payment financing, are suggested to be examined in future studies. Change in technology to empower SC integration and innovation is argued as new resolutions field to enhance the SC finance as there are plentiful opportunities to improve revenues through developing financial flows such as digital technologies, the Internet of Things, cloud computing and big data, blockchain (Chen et al., 2020b). Dealing with sharing knowledge and information problems can be effective tools to control cash flow, share the financial risk and lower financing cost within SC to unravel material inequalities and strengthen the financial operational system. Learning from bankruptcy factors to proposed financial preparedness, financial resilient ability to disruption must be emphasized as an important aspect of SCCM. How to assurethe cash flow quality to help consumers to increase and re-claim their trust to suppliers since they are unaware in production chain, itineraries, and threat in manufacturing, inventory, and transportation and delivery in essential.

5.1.4. Supply chain flexibility

Flexibility is the capability to react to long-term or essential SC fluctuations or market environment such as technological, ecological, demand and supply changes by adjusting the SC configuration (Eckstein et al., 2015; Blome et al., 2014). It involves changes in the orders time and quantity to suppliers, deviations in production volume, and in production mix (Esmaeilikia et al., 2014; Swafford et al., 2008). SC flexibility requires flexibility at the level of individual firms in the system (Duclos et al., 2003, Ngai et al., 2011). The concept has dual functions, involving both reactive response to present changes and proactive anticipation of future ones (Rojo et al., 2016). The construct encompasses (1) sourcing flexibility, as the ability to obtain available materials and service in the fluctuating conditions midst; (2) operating system flexibility, to offer products/services that have sufficiently extensive variety so that any customer specifications can be satisfied; (3) the distribution flexibility, as the organizational capability to proficiently accomplish the inventory, loading, and distribution system, and other facilities and information system to react quickly to changing conditions, especially those unexpected errors (Moon et al., 2012). This has risen an increased motivation on the SCs contribution to the total organization competitiveness, referring as the essential restrictions in business to consider flexibility as discrete individual, rather than the interdependencies among SC partners (Delic & Eyers, 2020).

SC flexibility is a relevant study topic in SC management, having this as a critical indicator to achieve and unsure a sustainable competitive advantage in the current dynamic, uncertain, and unpredictable environment (Mota et al., 2015; Burin et al., 2020). Firms can achieve higher competitive advantages when its mix resources functions are varied, precise, difficult to duplicate, to create greater value for customers than its rivals. Enabling capabilities as potential distinction source that directly allied with the SC flexibilities could create more advanced competitive advantages (Gosling et al., 2010; Scavarda et al., 2010). For instances, flexible information technology can instantaneously provide speedy outcomes to support sustainable growth in an intensively dynamic environment, avoid influences on organizational performance by immobilizing the organizational behavior patterns and monitoring that determinedly refrain the disruption (Biloslavo et al., 2013). Competitive advantages are ensured through the available resources control and acquisition, thus creating long-term sustainable performance (Chan et al., 2017).

However, studies on SC flexibility role in diminishing SC risk have empirically been scarce, making manufacturers struggles in incessant improvements in SC to minimize the negative effects of product variety and customization on the performance of the SC (Um, 2017, Sreedevi & Saranga, 2017). Particularly, it is argued that to remain competitive, firms are increasingly adopting strategies of exploration to seek new opportunities and exploitation to utilize prevailing capabilities and resources (Aslam et al., 2018). Still, the correlation between exploration and exploitation has not been clearly discussed. Academics claim decision-makers often face trade-offs between efficiency and flexibility giving partiality to one over the other is prejudicial (Wamba et al., 2020). Firms are argued to engage in flexibility strategies and competence to develop an ambidexterity capability (Ojha et al., 2018). The lack of integrated framework that be identical to diverse processes of SC management and explains how flexibility affects firms' performance have not yet to be fulfill.

The process integration apprehension requires information incorporation and strategic alliances in SC eco-design to improve flexibility completeness (Wu et al, 2017). In lieu of this, SC reconfiguration is proposed as strategic affiliation pushing firms to facilitate the flexibility function during post-disruption procedure. An organizational reconfiguration resources, capabilities and internal structures and a re-structure of organizational goals, values and practices are necessary to pay more attentions (Kim and Toya, 2019; Weijiao et al., 2018; Shah et al., 2020). The uncertainty and product diversification are important to improve SC to respond demand variations. As a result, production flexibility strategies and responsiveness has become potential topics for investigation as the factors of SC flexibility (Gunasekaran et al., 2016). Learning from the recovery stage in concerned with dynamic modifications and stabilization to the limited resources allocation to ensure process continuity, flexibility and redundancy development in building SSCM is needed (Gupta et al., 2015; Ivanov et al, 2017).

5.1.5. Supply chain resilience

SC resilience define as the SC adaptive ability to respond to disruptions, react to unexpected occasions, and then recover by continuously maintaining operations at the desired balanced of connectedness and control over the SC function and structure (Ponomarov and Holcomb, 2009). The concept correspondingly measures the recovery speed of the SC after corrupting by enduring interference preservation occupations, and the multi-dimensional sub-system switching level (Sprecher et al., 2015).Different from the concept of SC agility and flexibility, the resilience is desired for firms to survive despite resisting a continuing and unembellished effects from the environment changes. While some scholars have captured SC resilience as a multi-dimensional structure, which has stronger relations with both risk and market performance at high levels of supply-side, disastrous disruptions, infrastructure, and financial performance, which is highly depending on disruptions forms (Kwak et al., 2018; Wong et al., 2019). The others are conceptualized it by scope of SC network, as SC resilience a multi-layered paradigm that involves upstream suppliers, focal internal firm, and downstream customer resilience components (Pettit et al., 2019).

The resilience is used in material science and presently is widely used in manufacturing, communication and information discipline, and energy (Gasser et al., 2019; He et al., 2017). The concept is critical for firms to construct as a fundamental capability to respond to uncertainties, challenges, and the absolute extent of disruptions and harsh conditions to create sustainable value for the SC long-term survival and performance (Gölgeci & Kuivalainen, 2020). The balanced resilience is essential to the equilibrium between increasing firms' capabilities and surplus costs in controlling vulnerabilities (Pettit et al., 2013). Risk management and market performance as firms face both internal and external effects, resilience capability helps them to ease the pressure from the disruption and ambidexter to the original state (Wong et al., 2019). Thus, SC resilience is also referred as dynamic capability enables the SC to adapt, respond and recover effectively after disruptions and thereby increase the company's competitive advantage (Yu et al., 2019). The concept needs an ingenious SC network with reactive and proactive capabilities, allowing members to decrease the likelihood of disruption wave or their impact to taking firms to a stronger sustainable performance (Chowdhury & Quaddus, 2017).

Although the literature has been extant provided, there is still a lack of measurement assess that can evaluate the SC resilience since most of the studies obtained are weak in objective composition, which rarely be implemented in actual conditions (Chen et al., 2020a). Resilience of a SC network from empirical viewpoint is important due to operational risks such as financial constraints, material problems, non-cooperation from suppliers, or lack of quality human resource (Dixit et al., 2020). Uncertainty and the lack of information is threating a firm's activities and sustainable existence, emphasize on the collaboration, data sharing and knowledge creation are needed. Studies on adaptability and absorptive capacity can help firms acquire and utilize knowledge to respond to unexpected or sustained difficulties, and in recovery by providing resilience. Developing new manufacturing paradigms, foster such industrial Internet and cyber-physical technologies in the SC resilience can lead to more smart, personalized, and sustainable mechanism (Biswas et al., 2019). Simultaneously, the non-existence or low disastrous disruption utilize little capacity of SC resilience likely resulting in insignificant performance improvement. there is little sympathetic on business and strategic values of possessing

SC resilience as a capacity to preserve and obtain resources and utilize them to alleviate disruptions effects (Wong et al., 2019). The directions for resource specification, resource mix, the principles of resource measurement utilization for SC resilience are still scarce in both qualitative and quantitative approaches, especially in dealing with widespread disruptions. Besides, the collaborative and technical integrated relationships keen on positive outcomes are recommended for maintaining or securing competitive advantage. As SC resilience measurement is important to reduce order losses, the composition of the SC operating in the interrupted environment, measurement model of SC resilience is needed. Compositing the models that measures SC resilience operation to sustain a high level of performance in an interrupted environment is critical.

5.1.6. Sustainability

SSCM has grown significantly and has become a subject of increased concern due to a global population explosion, resource limitations, logistics production and consumption activities corruption, and waste and pollution increase (Rebs et al., 2019). As disruption events such as economic crises, terrorist attacks, earthquakes, and pandemic occurred more severity and frequency, the sustainability is becoming more crucial for SC due to uncertainty created (Ivanov et al. 2016, Fattahi et al., 2020). Firms are now facing higher levels of risk as disruptions considerably influence SC performance (Blackhurst et al., 2011; Dubey et al., 2018). Therefore, the TBL must be further distinguished.

The economic sustainability is resolute by the SC interaction on an intra- and inter-organizational, and extensive industrial aggregate level related to goods and financial flows regenerating by natural, social and economic resource within organizational boundaries (Fabbe-Costes et al., 2011; Brandenburg et al., 2014, Schaltegger et al., 2016). However, the economic effects of disruptions have grown causing economic losses rapidly increase and intensify among the global manufacturing and business connectivity (Hughes et al., 2019; Senyo et al., 2019). Firms are argued to pursue an inter-organizational orientation of processes to provide economic and competitive advantages to minimize the disruption effects across SCs and integration (Revilla and Saenz, 2017; Munir et al., 2020). Thus, develop new products design, innovating manufacturing model access to capabilities in managing new technologies and process reconfiguration is potential to invest on. Information technologies and technical architectural compositions to gain economic benefits requires broad and deep understanding (Smeda, 2017, Hajli et al., 2020). New business models, thus, need to be comprised to deliver more value creation such as financial (cost and profit, macroeconomic variables, and non-financial attributes such as product quality and quantity distance, routing transportation.

While there has been progresses the links between SSCM and economic sustainability, there are only few studies have addressed the social and environmental sustainability measures. Increasing social and environmental sustainability performance may become a competitive advantage to achieve economic performance. Social systems and environmental resources construct and control the intra- and inter-organizational SC as essential parts of economic systems. Particularly, social sustainability performance has been emphasized in the literature, which means achieving economic and environmental sustainability objectives (Beske-Janssen et al., 2015; Walker et al., 2014). From the internal approach, there is a lack of study on labor conditions and other social factors often create stress as if the unequal distributional benefits are obvious, such as regulatory changes, or technical interruptions issues (Hoffmann et al., 2020). As social context acquires organizational supports, the employees’ behavior such as trust and willingness, open-mindedness and advance assistance among staff, employees' reliance, and commitment are required more attentions. The leadership transformation to provide the organizational performance that enables SC partners to achieve ambidexterity are suggested (Ojha et al., 2018).

On the other, the external factors of social SSCM has also been growing due to environmental resources constrains and rising global population challenge production and logistics activities consume available resources and increase waste and pollution. The social network between SC partners acts as an asset protection against spur cooperative action, adversities, and help firms to stopover sudden disruptions (Aldrich and Meyer, 2015). The relational aspect of trust and social capital are considered to motivate external resources sharing and exchanging derived from social relationships under the alignment contingency to help the firm to recover from the shock faster if there were unexpected events or disruptions (Gölgeci & Kuivalainen, 2020). Still, studies on enablers of the emergence of social formative capabilities in disaster survival and recovery are in weak evidence. Highlighting on trust and shared cooperative mechanism among partners to avoid conflict management and produce inconsistency have yet to be fully explored. Even though there is suggested that extensive social networks could deliver knowledge benefits conducive to ambidexterity, the role of knowledge creation aspect such as strategic information flow, big data between SC ambidexterity and SSCM performance have not been solve in the literature (Partanen et al., 2020). Overall, there is little known about how to utilize social sustainability to face the harsh and turbulence conditions.

Pollution prevention practices results in better operational performance of cost, quality, and reliability. The higher firm’s level of innovation is, the better cost saving it gains from environmental sustainability practices (Yusuf et al., 2020). In particular, the effective green and products development relates to difference strategies is suggested to minimizing the environmental impacts of the SC while encompassing the triple-bottom line objectives (Dües et al., 2013; Prajogo et al. 2014). This aims to reduce the ecological effects as well as promoting the long-term financial benefits (Marshall et al., 2015). Yet, there are absence of regulations and policies of wasteful materials, water, energy utilization that are not only damaging the environment but changing climate, thus exerting SCs vulnerability and compressions on manufacturers. the environmentally friendly policy to shape business activities and wider sustainability issues must be developed. Green SC design and optimization approach that involves multi-product, and suppliers and buyer's selection, quality control policies and a model to manage consign inventory agreement should be considered as tools to rapid respond to the markets changes. Additional, very few studies have looked at how firm recovers after the disruption follows structural initiatives such as of human and technical lean practices implementation (Shah et al., 2020). Therefore, lean innovation strategies accumulate from integrating approaches is argued to substantially reducte pollution during manufacturing process and improvement green process performance. Collaboration on the environmental enhancement in terms of process integration, green raw materials, eco-product design, and customer-based need to have further measures (Tseng et al., 2015).

However, sustainability likewise has negative impact on firms' profitability indicating a need to find ways to maximize the performance advantage of implementation of sustainability practices (Esfahbodi et al., 2017; Green et al., 2015). The challenge is how to integrate those TBL to develop unique abilities to enhance sustainable competitive advantage throughout the disruption and ambidexterity (Yusuf et al., 2020). While the integration has been argued to provide economic and competitive advantages, yet, those advantages come with abundance of unpredicted risks due to the alternating processes, thus leading to inconsistent among SC performance (Munir et al., 2020). This rises pressure to secure sustainability and creates opportunities for recovery. Focusing on streams of studies of ambidextrous SC strategy, exploitation, exploration, customer satisfaction; governance ambidexterity; financial ability, the integration between SC agility; adaptability; resilience, as well as such dynamic strategy; the linkage of firm's knowledge to its operational process, and its partners to be its uniqueness to deal with unexpected disruption or sustained adversity are urgently essential.

5.2. Regional discussions

The regions show different tendencies compared with others. It is reported that show Asia and Oceania, Latin America and the Caribbean, and Africa are the regions that needs to be improved. In particular, Latin America and the Caribbean, and Africa have fewer publications in the field; while Asia and Oceania, which has the largest among regions, also show much room for improvement due to its sensitive position in the global SC. Despite Europe and North America are reported to have less demand for improvement, still, these regions show distinct apprehensions on SCND beside the other common trends.

5.2.1. Asia and Oceania

Asia and Oceania are a dynamic region, which is known as the heart of global SC since half of the global total industry value is produced from this region. As export-oriented area, Asia and Oceania has extraordinary economic growth power thanks to its multifaceted SCs network. The region is not only considered as a main manufacturer of components and products but also plays as a major global consumer market. However, the region's SCs are integrally weak to interruption causing deleterious effects on operational system, suspended exports, and facing various of vulnerable challenges. Such uncertainty vulnerability as disaster risk, pandemic, high geo-political tensions, increasing military maneuvering is potential to disrupt trade and business continuity, scattered phases of panic buying, and threaten human and employee safety, making the SC more sensitive and fragile, thus, reduces the entire global SC capacity.

Thus, post-disruption and ambidexterity actions with strong scientific consensus in advance planning, clear disaster response responsibilities understanding, and strategic coordination is possible to improve the situation. Building SC resilience, agility, flexibility; investing on business continuity planning, and appropriate procedures to ensure the sustainable operational steadiness can help firms successfully manage the SC disruptions impact. Scenario planning involves key uncertainties, SC re-design from employment, transportation and logistics availability to determine firm's preparation for conceivable upcoming events is recommended to strengthen their capability. Firms need quality and trustworthy information to handle the complex and uncertain environment frequently changing (Munir et al., 2020). Further studies on transparency to reflect on and implement better policies and knowledge, improving collaboration and cooperation with regional-international and local governments, and developing better communication channels is argued to better manage risk and in-depth the relationships between suppliers. To do so, the information technology concentrating on three stages of handling the disruptions consisting disruption discovery, post occurrence, and disruption recovery cannot be ignored (Chen et al., 2019). Blockchain technology, social media exploitation can help firms to enhance the SCs and better position them to respond to crises. Emphasizing on analytical strategic foresight, simulating the inherent unpredictability events to build evaluation capability to potential risks so that can ensure improvements and better prepare themselves for infrastructure-related disruptions is recommended.

5.2.2. Africa

Africa can be assumed to be less experiences SC disruptions due to less connecting to global SCs. Yet, the region's economy might receive hard stroke by its largest trade partner as China are losing the fundamental place in global supply. Furthermore, the manufacturing and transport equipment are largely imported making Africa have been seriously obstructed by both key components supply decrease from Asia and other regions and reduction in global products demand. SC disruptions with raw material shortages, delays, fall of orders, costs increase, and other economic consequences causing further vagueness contending with extensive of geopolitical instable are probably to initiate SCs function reconsideration and strengthening regional operations. This pushes the region must realign and devolve its SC to a boarder international cooperation and stronger flexibility and resilience as the conceivable approaches.

The region has shown inimitable, wide-ranging, and incessant challenges to build its SC abilities to adapt the post-disruption stage. Africa's economic conditions in recent years and its extensive natural-resources abundance have stimulated SC finance development with higher returns than other regions. However, the logistics infrastructure quality and technological capabilities are heterogeneous across the region marking the urgent of long-term structural shifts to synchronize with global SCs. Still, the studies on this region are relatively less. Gaps in improving service reliability, synergies and partnership opportunities to ensure the shared costs and benefits between SC channels need to be accomplish. Strategies on controlling and managing the human resources, skills and experiences to enhancing the technical processes and impose international standards and ensure sustainability for business development are requiring further examinations. How to adopt economic agreements advantages and trade corridors rising for firms to achieve economies distribution must be approached.

5.2.3. Latin America and Caribbean

Latin American and Caribbean are in quest of SC improvements of demand, operations planning, transportation, inventory replenishment, and sales since the region faces operational risks due to SC disruptions issues like financial volatility, market, security factors, quality diminish, infrastructural barriers, and transparency problems. A systematic approach is needed for firms to respond to urgent process obtaining, adapt to disruption scenarios, and obey with operational restrictions. However, the engagement level with between firms and government has deteriorated with significant augmented of risk compliance. Firms struggles to leverage out-of-date and encumbered resource planning systems to tackle complexity making a slow advanced SC solutions adoption. The emerging technologies has cause uncertainty, haziness, and inconsistency disrupt firms' operational models and the dynamic business anxieties (Hoffmann et al., 2020). This pressure on the region to adopt new SC practices and devices to collaborate with their international partners, increasing competitive advantages in global markets and profitability.

The Latin America and Caribbean are potential workshop to replace Asia for North America and Europe. The certitude and operative constancy must be noticed when building resilience and flexibility approaches, which positively improve operational efficiency (Ivanov and Dolgui, 2019, Essuman et al., 2020). However, the lack of information and uncertainty, and the absence of the external knowledge are navigating their activities and unsustain their existence. This require is a clear direction on sustainable competitive strategy and SC tactic. In practice, the international SC finance variations become to price modification anticipations with potential of abrupt depreciations. Studies on agility design, public policies operation, investment decisions, reliable national establishment on cost evaluation, private sector strategic decision-making process are an effective innovation to acquire and process the recovering of external shudder against uncertainty and difficulty (Gölgeci & Kuivalainen, 2020). An integrated effective solution is important to guarantee a proper level of SC when facing unexpected events.

5.2.4. North America

The unforecastable feature of disruption impacts on the SC operations in North America causing widespread apprehension and economic adversity such as steeply increasing or losing demand, generating uncertainty, weakening delivery ability, absences of logistics capability. In this region, raw materials and intermediate commodities are outsourced and transferred around the world and then assembled in another place, the final output is then re-exported to final consumers. Accordingly, SC activities are fronting problems in dealing with interruptions as the immediate effects of using overseas manufacturing making firms to restructure SC. In fact, the disruption may have two-site effects to the SC as it helps to accelerate the jobs return to North America in long-term due to global uncertainties, while in the short term, it's contrarily cause reduce of production due to deteriorating of components arrivals and manufacturing delays.

Therefore, reconfiguring the SC network design considering both short-term and long-term accomplishments are required to recover the post-crisis SC performance. Develop SC disruption administration plans, classify crisis strategies, implement new SC models and assessing substitute outbound logistics possibilities must be focus on. Determining factors impacting the international SCs dynamics can help to ensure supply continuity. Qualitative and quantitative SC risk analysis approaches are important to sustain market share, establishing demand-supply synchronization assessment. Evaluate the financial health, creating agility to measure the potential SC, determinate, reorganized with flexible SC networks might be potential study field. Investigate on technologies adoption across SC and support ability to resist sudden shocks is proposed. Identify geologically diverse for emergency considering should be given to both academia and practice. Implementing optimization models, addressing new metric on ambidexterity, highlighting design decisions, capabilities and infrastructure, as well as transportation link to create reliable and sustain SC network is necessary (Govindan et al. 2017; Dolgui et al. 2018; Fattahi et al, 2020).

5.2.5. Europe

Similar to North America, Europe is also critically suffered from supply-chain disruptions due to the global crisis, production shutdown, and supply-demand shocks. This essentially prompt a reconsideration of SCs function, emphasizing on implications of resilience and agility to both up-and-downstream SC members. Thus, future studies may focus on total employment assurance, experience firms growing constraints, just-in-time delivery; the flexibility in evaluate and supervise the SC production quality. Implementing digitization and cyberization within SC may help the region to utilize its global resources, achieve greater transparency, stay close to the consumers and improve sustainability during and after the disruption. However, instantaneous attempts to reposition the network may interruption reinstating occupied production as the result of finding alternative suppliers and redesigning deliveries system with long-lasting, overpriced and spoiled uncertainty. The resilience cannot depend on self-sufficiency but supporting regional integration.

Since the region is the main importer from both Asia and Africa, and buys almost products from Latin America, the manufacturing activity collapses consequent in economic corollaries such as reduced inputs demand, materials exports decrease. As a domino effect, the global trade may decline due to the continuing SC disputes. The recovery of production line requires re-establishing existing links, removing temporary barriers put in place during the emergency, and ensuring an open and predictable world trading system. Hence, SCND is argued to be important not only for the region of North America or Europe but also all over the world to prepare for a high-tension disrupting condition. New models to take decisions on facility location, production capacity, facilities' changes and connection between echelons are crucial. Empirical studies on SC integrations to meet actual problems of outsourcing movements and interior tasks, as well as to ensure the SC efficiency in terms of production and information flows between partners are significant (Leuschner et al., 2013, Chatzikontidou et al., 2017).

6. Conclusion remarks

The evolution on sustainability has followed by an augmented understanding on the wide-ranging literature of the SSCM. However, the uncertain of global business fast-changing and operational strategies complication has caused high intensity of SC risks and vulnerability that leads to disrupting the whole SC. The importance of ambidexterity is argued to ease the disruptions impact and enhance business performance as SC members adapt to new customers demand and changing in business environment. Still, the complexity of different SC players has cause various impartialities, which distinct between different geographical regions, has posed great challenges to sustainability. It is essential to emphasize on the regional phenomena exploration aside from an overall review of the literature. A systematic review to classify state-of-the-art SSCM and release new directions and potential opportunities is necessary to foster further studies.

Quantitative and qualitative approaches are proposed through a hybrid method of content and bibliometric analyses , FDM, EWM, and fuzzy DEMATEL to (1) scanning the SSCM literature towards disruption and ambidexterity, (2) to determine data-driven indicators for future debates and study trends, (3) to identify the challenges and knowledge gaps between geographical regions. The content analysis is used to criticize the publication data driven from the Scopus database. The bibliometric analysis applied the VOSviewer software to graph a bibliometric overview and identified the SSCM indicators. The FDM is used to refine the valid indicators by computing their perception levels from experts' linguistic references. The EWM is applied to convert the indicator occurrence information into comparable weights to determine the indicator performance among regions. The fuzzy DEMATEL is used to obtain human linguistic perceptions and identify the substantial indicators for further studies. This study contributes to a SSCM review toward disruption and ambidexterity, distinguish the critical indicators as gaps to offer supplemental knowledge that supports future studies and practical implementations. In this study:

- A data-driven analysis is delivered and determined the critical indicators as gaps for future studies. There are 273 keywords listed and 22 indicators are obtained based on the experts' evaluation. The most important indicators are emphasized as essential for future directions.
- The prioritization for investigation occasions is proposed for future study to investigate, the relationship between the trends and challenges are clear addressed in this study. By ocusing on ambidextrous SC strategy, involving SC agility, SC coordination, SC finance, SC flexibility, SC resilience, sustainability the knowledge linkages are processed to deal with unexpected disruption or sustained adversity.
- The identified gaps between geographical regions offer both to local viewpoints and the comprehensive global state of the art of SSCM. There are 1 countries/territories are accumulated to 5 regions, including Asia and Oceania, Europe, North America, Latin America and Caribbean, and Africa. The results showed that Asia and Oceania have the highest number of SSCM publications, followed by Europe and North America. Latin America and the Caribbean and Africa displayed fewer publications compared with others.
- A studies trends comparison is emphasizing on the regional viewpoints. Latin America and the Caribbean, and Africa are required for significant enhancement; while Asia and Oceania also show gaps for improvement due to its sensitive position in the global SC. The Europe and North America show fewer demand for improvement, still, these regions show distinct apprehensions on SCND beside the other common trends.
- The SSCM actors can refer to this study as a reference for decision making. Firms, governments and professionals can esteem provided information from this study to promote policy strategies, practical design and planning based on regional and overall insights to foster innovative implementations.

Some limitations exist in this study. First, the authors. It is difficult to guarantee adequate examination because this study was unable to inspect all 2402 publications driven from the database. Second, the discussions may lack to initiate sufficiency assessment because Scopus also contains low impact sources (Shukla et al., 2019). A future study is recommended to engage a more condensed database for better results. Third, there are only 30 members in expert committee, which may cause the analysis favoritisms process due to their knowledge, experience, and familiarity to the study field. Increasing the volume of respondents is proposed to avoid this problem. Both academic and practical investigation is encouraged to exploit this study's exhaustive method in another field for data-driven analysis.

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Table 1. Transformation table of linguistic terms for FDM.

Linguistic terms (performance/importance)	Corresponding triangular fuzzy numbers (TFNs)
Extreme	(0.75, 1.0, 1.0)
Demonstrated	(0.5, 0.75, 1.0)
Strong	(0.25, 0.5, 0.75)
Moderate	(0, 0.25, 0.5)
Equal	(0, 0, 0.25)

Table 2. TFNs linguistic scale for fuzzy DEMATEL

Scale	Linguistic terms	Corresponding TFNs
1	No influence	(0.0, 0.1, 0.3)
2	Very low influence	(0.1, 0.3, 0.5)
3	Low influence	(0.3, 0.5, 0.7)
4	High influence	(0.5, 0.7, 0.9)
5	Very high influence	(0.7, 0.9, 1.0)

Table 3. Final List of FDM indicator result

ID	Indicators	Description	Related works
I1	Adaptability	Adaptability is the willingness to reshape supply chains when necessary, without ties or legacy issues or regard to how the chain has been operated previously	Ketchen and Hult (2007); Sheel & Nath (2019); Jermsittiparsert & Pithuk (2019); Piri et al. (2018); Wamba et al. (2020); Aslam et al. (2020).
I2	Chaos control	Chaos is a complex nonlinear dynamic phenomenon, which is widely used in complex systems in different fields of SC such as engineering, economics, biology, and chemistry; hence, it is crucial to seek a method to control the chaotic dynamic system.	Ma & Li (2020) ; Kocamaz et al. (2016); Ma et al. (2016); Chen & MA (2014); Xu & Ma (2020); Tian et al. (2020); Ma & Li (2020).
I3	Competitive advantage	Competitive advantage is the extent to which an organization is able to create a defensible position over its competitors	Liao et al. (2017); Montshiwa & Nagahira (2015); Princes (2020); Sheel & Nath (2019); Singh & Singh (2019); Dubey et al. (2019).
I4	Disaster management	The concept of disaster management can be defined as the correct set of actions and activities taken during each phase of the disaster extending between preventing the disaster from happening to overcoming its effects.	Abulnour (2014); Dwivedi et al. (2018); Ganguly et al. (2017); Rodríguez-Espíndola et al. (2020); Ghorashi et al. (2019); Gupta et al. (2020); Khalilpourazari et al. (2020); Govindan et al. (2020b); Sarma et al. (2020); Schätter et al. (2019).
I5	Green supply chain	Green supply chain management is defined as a set of programs adopted within the supply chain to improve environmental performance of processes and products in the forms of environmental management system, life-cycle analysis, design for environment, environmental certification.	De giovanni & Vinzi, (2020); Fazli-Khalaf et al. (2017); Kim & Chai (2017); Muduli & Barve (2015); Mangla et al. (2015); Ortas et al. (2014); Mari et al. (2014); Xia et al. (2020); Aslani & Heydari (2019); Zhang et al. (2017).
I6	Lean	Lean is defined as a set of practices focused on waste reduction and elimination of non-value-added activities, has been historically known and appreciated for its contribution to the firms' performance	De giovanni & Vinzi, 2020; Qamar et al. (2019); De Sanctis et al. (2018); Lotfi & Saghiri (2018); Balaman (2016). Birkie (2016); Brown et al. (2015); Zuting et al. (2014); Rashad & Nedelko (2020); Haddud & Khare (2020); Ivanov (2020); Divsalar et al. (2020); Roy & Roy (2019); van Blokland et al. (2019).
I7	Social responsibility	Social sustainability is one of the pillars of the TBL, addresses three points: well-being of human beings, society, and safety of consumers.	Govindan et al. (2020a); Yang et al. (2020); Chan et al. (2020); Zhang et al. (2020); Ardakani et al. (2020); Morsing & Spence (2019); Hosseini-Motlagh et al. (2019); Tong et al. (2018); Comyns & Franklin-Johnson (2018); Barclay & Miller (2018); Scheper (2017); Fazli-Khalaf & Hamidieh (2017); Wu et al. (2017); Cordell et al. (2015); Ortas et al. (2014).

I8	Supply chain agility	SC agility refers to the capability to deal with unexpected short-term, temporary changes as well as to rapidly acclimatize to those changes in SC and market environment.	Aslam et al. (2018); Eckstein et al. (2015); Wamba et al. (2020); Aslam et al. (2020); Shukor et al. (2020); Alzoubi & Yanamandra (2020); Suresh et al. (2020); Aslam et al. (2018); Shqairat & Sundarakani (2018); Tuan (2016); Liu et al. (2015b).
I9	Supply chain ambidexterity	SC ambidexterity refers to a manufacturer's efforts to refine/extend its existing resources and to develop new supply chain competencies and yield performance benefits, especially for large manufacturing firms	Partanen et al. (2020); Partanen et al. (2020); Aslam et al. (2020); Ojha et al. (2018); Lee & Rha (2016); Princes (2020); Pu et al. (2018); Burin et al. (2020); Souza-Luz & (2019); Güemes-Castorena & Ruiz-Monroy (2020); Makhashen et al. (2020); Shams et al. (2020); Yalcin et al. (2019); Goh & Eldridge (2019); Im et al. (2019); Qamar et al. (2019).
I10	Supply chain collaboration	SC collaboration is a model in which members of the supply chain share risks and resources in order to improve the competitive advantage of the entire supply chain.	Manthou et al. (2004); Im et al. (2019); Al-Doori (2019); Adem et al. (2018); Namdar et al. (2018); Zhu et al. (2017); Aggarwal et al. (2020); Birkel & Hartmann (2020); Rashad & Nedelko (2020); Scholten & Schilder (2015); Gabler et al. (2017); Chen et al. (2017); Silvestre et al. (2018); Nassar et al. (2019).
I11	Supply chain coordination	SC coordination describes collective efforts to reach goals, which is “the act of managing dependencies between entities and the joint effort of entities working together towards mutually defined goals.”	Li et al. (2018); Zhao et al. (2020); Hosseini-Motlagh et al. (2020); Heydari et al. (2019); Hosseini-Motlagh et al. (2019); Oliveira & Handfield (2019); Esmaeili-Najafabadi et al. (2019); Liu et al. (2017); Wang et al. (2017); Li et al. (2017); Danusantoso & Moses (2016); Xiao & Chen (2016); Ali & Nakade (2016); Zheng et al. (2015); Mortazavi et al. (2015); Watanabe & Kusukawa (2015); Chen et al. (2020); Chakraborty et al. (2020); Zhao et al. (2020).
I12	Supply chain disruptions	SC disruptions are undesired and unexpected events; examples include natural disasters, industrial accidents, technological shifts, and political events	Braunscheidel and Suresh (2009); Kumaran et al. (2020); Parast (2020); Paul & Chowdhury (2020); Messina et al. (2020); Nguyen et al. (2020); Zhu et al. (2020); Handfield et al. (2020); Govindan et al. (2020b); Kumar & Anbanandam (2020); Salmi et al. (2020); Azadegan et al. (2020); Birkel & Hartmann (2020); Sheu & Kuo (2020); Wamba & Queiroz (2020); Jahani et al. (2020); Polyviou et al. (2019); Queiroz et al. (2019); Ni et al. (2019).
I13	Supply chain dynamics	SC dynamics can be grouped into linear dynamics and nonlinear dynamics; (1) linear dynamics, such as stability, can be studied with control engineering methods, and (2) nonlinear dynamics, for example, chaos, have been investigated mostly by simulation experiments.	Wei et al. (2013); Lohmer et al. (2020); Kinra et al. (2020); Hosseini et al. (2020); Ivanov, (2020); Ivanov & Dolgui (2020); Dolgui et al. (2020); Olivares-Aguila & ElMaraghy (2020); Nilakantan (2019); Palma et al. (2019); Ivanov et al. (2019); Ivanov et al. (2018); Ivanov (2018); Dolgui et al. (2018); Udenio et al. (2015); Hwarng & Yuan (2014).
I14	Supply chain finance	SC finance toward the sustainability is described as financial mechanism offers such business transactions to minimize negative effects and generate more environmental, social, and economic values for the SC.	Gupta & Chutani (2020); Yan et al. (2020); Chen & Wang (2020); Doan & Bui (2020); Chen et al. (2020); Filbeck et al. (2016).
I15	Supply chain flexibility	SC flexibility is the capability to react to long-term or essential SC fluctuations or market environment	Eckstein et al. (2015); Blome et al. (2014); Rojo-Gallego-Burin et al. (2020); Burin et al. (2020); Mandal (2015); Sahu et al. (2015); Huang & Lu (2020); Pu et al. (2018); Shekarian et al. (2020); Shekarian & Mellat Parast (2020); Baharmand et al. (2019); Shen et al. (2019).

		such as technological, ecological, demand and supply changes by adjusting the sc configuration.	
I16	Supply chain integration	SC integration is defined as the strategic collaboration with supply chain partners besides aligning intra-organizational practices related to flow and production of products, services, information and joint decision-making in various functional areas inside (internal integration) and outside firm boundaries (supplier and customer integration)	Shah et al. (2020); Scott (2016); Munir et al. (2020); Shukor et al. (2020), Syed et al. (2019); da Silva Poberschnigg et al. (2020); Durowoju et al. (2020); de Freitas et al. (2019); Palm et al. (2020); Magill et al. (2020).
I17	Supply chain network design	SC network design represents the facility location problem, and SC management contains facility location determination, magnitude, network capabilities and the material flow among the located facilities.	Pishvaee and Razmi (2012); Fattahi et al. (2020b); Benedito et al. (2020); Hamdan & Diabat (2020); Fazli-Khalaf et al. (2019); Diabat et al. (2019); Snoeck et al. (2019); Li & Zhang (2018); Jabbarzadeh et al. (2018); Fattahi et al. (2017); Jabbarzadeh et al. (2013); Azad (2014); Hasani et al. (2020); Nezamoddini et al. (2020).
I18	Supply chain resilience	SC resilience define as the SC adaptive ability to respond to disruptions, react to unexpected occasions, and then recover by continuously maintaining operations at the desired balanced of connectedness and control over the SC function and structure.	Ponomarov and Holcomb (2009); Remko (2020); Kumar & Anbanandam (2020); Asamoah et al. (2020); Kahiluoto et al. (2020); Aslam et al. (2020); Shekarian & Mellat Parast (2020); Piprani et al. (2020); Mohammed et al. (2020); Yu et al. (2019); Ivanov & Sokolov (2019); Tan et al. (2019); López & Ishizaka. (2019); Thomas & Mahanty (2019); Mikhail et al. (2019); Singh et al. (2019); Scholten et al. (2019); Bevilacqua et al. (2019); Rajesh (2016); Hosseini & Ivanov (2020); Behzadi et al. (2020); Lohmer et al. (2020); Li & Zobel (2020).
I19	Supply chain risk management	SC risk management refers to the coordinated approach among the members of a supply chain for identifying and managing supply chain risk in order to reduce supply chain vulnerability	Jüttner et al. (2003); Munir et al. (2020); Birkel & Hartmann (2020); Roscoe et al. (2020); Kbah et al. (2020); Shahbaz et al. (2020); Baryannis et al. (2019); Chowdhury et al. (2019); Snoeck et al. 2019). Sawik, T. (2019b); Mogos et al. (2019); Stewart & Ivanov (2019); Gao et al. (2019); Shahbaz et al. (2019); Sawik (2019a); Bugert & Lasch (2018); Nakatani et al. (2018); Kumar et al. (2018); Ledwoch, et al. (2018); Blackhurst et al. (2018); Diabat et al. (2019).
I20	Supply chain vulnerability	SC vulnerability is the susceptibility or exposure to a disruptive event in the supply chain	Blackhurst et al. (2018); Azadegan et al. (2020); Viljoen & Joubert (2018); Nakatani et al. (2018); Konig & Spinler (2016); Chowdhury & Quaddus (2016); Chen et al. (2015b); Ethirajan et al. (2020).
I21	Sustainability	Sustainability in the SC is defined as managing the supply chain functions aligned with the social, environmental, and economic sustainability requirements of the stakeholders to reduce sustainability risks in supply chain and improve market performance	Seuring & Müller (2008); Sharifi et al. (2020); Chatterjee & Layton (2020); Chen et al. (2020); Handfield et al. (2020); Zhu & Krikke (2020); Kamble et al. (2020); Niu et al. (2020); Quayson et al. (2020); Ivanov (2020); Shareef et al. (2020); He et al. (2020); Nayak & Dhaigude (2019); Maiyar & Thakkar (2020).
I22	Uncertainty	"Uncertainty" refers to a state that cannot be directly expressed by a certain amount of information, which describes a situation that	Liao et al. (2019); Sato et al. (2020); Samani et al. (2020); Goodarzian et al. (2020); Sureeyatanapas et al. (2020); Dutta & Shrivastava (2020); Paul et al. (2020); Fattahi & Govindan (2020); Darby et al. (2020); Soren & Shastri (2019); Salehi et al. (2019); Xiao et al. (2019); Uddin & Huynh (2019);

	cannot be ascertained, or where there are different possibilities.	Pashapour et al. (2019); Diabat et al. (2019); Alvarado-Vargas & Kelley (2019); Sreedevi & Saranga (2017).

Table 4. Regional entropy weights

	Indicators	Asia and Oceania	Europe	North America	Latin America and Caribbean	Africa	Overall
I1	Adaptability	0.045466	0.045465	0.045464	0.045463	0.045449	0.045461
I2	Chaos control	0.045452	0.045474	0.045472	0.045479	0.045485	0.045473
I3	Competitive advantage	0.045472	0.045480	0.045476	0.045485	0.045476	0.045478
I4	Disaster management	0.045425	0.045437	0.045407	0.045441	0.045413	0.045425
I5	Green supply chain	0.045471	0.045460	0.045466	0.045463	0.045485	0.045469
I6	Lean	0.045475	0.045470	0.045472	0.045474	0.045485	0.045475
I7	Social responsibility	0.045473	0.045471	0.045479	0.045474	0.045476	0.045475
I8	Supply chain agility	0.045466	0.045474	0.045472	0.045474	0.045440	0.045465
I9	Supply chain ambidexterity	0.045464	0.045462	0.045461	0.045474	0.045476	0.045467
I10	Supply chain collaboration	0.045456	0.045454	0.045460	0.045457	0.045449	0.045455
I11	Supply chain coordination	0.045443	0.045464	0.045461	0.045479	0.045476	0.045465
I12	Supply chain disruptions	0.045442	0.045438	0.045420	0.045413	0.045396	0.045422
I13	Supply chain dynamics	0.045447	0.045439	0.045466	0.045419	0.045449	0.045444
I14	Supply chain finance	0.045470	0.045478	0.045472	0.045474	0.045405	0.045460
I15	Supply chain flexibility	0.045461	0.045473	0.045458	0.045474	0.045467	0.045467
I16	Supply chain integration	0.045467	0.045466	0.045466	0.045457	0.045440	0.045459
I17	Supply chain network design	0.045448	0.045459	0.045447	0.045463	0.045485	0.045460
I18	Supply chain resilience	0.045437	0.045413	0.045439	0.045407	0.045422	0.045424
I19	Supply chain risk management	0.045433	0.045413	0.045426	0.045407	0.045458	0.045428
I20	Supply chain vulnerability	0.045460	0.045449	0.045449	0.045441	0.045449	0.045450
I21	Sustainability	0.045438	0.045424	0.045431	0.045424	0.045449	0.045433
I22	Uncertainty	0.045433	0.045439	0.045434	0.045457	0.045467	0.045446

Table 5. Region Entropy weight comparison

Indicators		Asia and Oceania	Europe	North America	Latin America and Caribbean	Africa
I1	Adaptability	↑	↑	↑	↑	↓
I2	Chaos control	↓	↑	↓	↑	↑
I3	Competitive advantage	↓	↑	↓	↑	↓
I4	Disaster management	↑	↑	↓	↑	↓
I5	Green supply chain	↑	↓	↓	↓	↑
I6	Lean	↓	↓	↓	↓	↑
I7	Social responsibility	↓	↓	↑	↓	↑
I8	Supply chain agility	↑	↑	↑	↑	↓
I9	Supply chain ambidexterity	↓	↓	↓	↑	↑
I10	Supply chain collaboration	↑	↓	↑	↑	↓
I11	Supply chain coordination	↓	↓	↓	↑	↑
I12	Supply chain disruptions	↑	↑	↓	↓	↓
I13	Supply chain dynamics	↑	↓	↑	↓	↑
I14	Supply chain finance	↑	↑	↑	↑	↓
I15	Supply chain flexibility	↓	↑	↓	↑	↑
I16	Supply chain integration	↑	↑	↑	↓	↓
I17	Supply chain network design	↓	↓	↓	↑	↑
I18	Supply chain resilience	↑	↓	↑	↓	↓
I19	Supply chain risk management	↑	↓	↓	↓	↑
I20	Supply chain vulnerability	↑	↓	↓	↓	↓
I21	Sustainability	↑	↓	↓	↓	↑
I22	Uncertainty	↓	↓	↓	↑	↑

Notes: ↑ *: above the average (Need for improvement)*
↓ *: below the average*

Table 6. Overall initial direction matrix

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16
I1	0.783	0.512	0.405	0.441	0.485	0.458	0.461	0.417	0.440	0.452	0.471	0.457	0.485	0.491	0.474	0.429
I2	0.561	0.762	0.507	0.568	0.511	0.489	0.502	0.450	0.504	0.500	0.485	0.551	0.537	0.563	0.534	0.486
I3	0.484	0.516	0.763	0.512	0.484	0.461	0.395	0.517	0.447	0.493	0.509	0.387	0.402	0.481	0.443	0.496
I4	0.580	0.516	0.499	0.801	0.548	0.534	0.499	0.546	0.517	0.536	0.544	0.504	0.491	0.513	0.557	0.564
I5	0.483	0.510	0.467	0.513	0.792	0.513	0.497	0.501	0.504	0.524	0.520	0.577	0.494	0.471	0.519	0.482
I6	0.369	0.492	0.441	0.515	0.527	0.795	0.504	0.510	0.504	0.381	0.494	0.397	0.473	0.377	0.548	0.476
I7	0.368	0.381	0.468	0.489	0.533	0.450	0.786	0.439	0.510	0.415	0.464	0.463	0.490	0.540	0.635	0.456
I8	0.413	0.519	0.456	0.473	0.501	0.531	0.445	0.784	0.514	0.370	0.542	0.319	0.422	0.405	0.497	0.675
I9	0.475	0.536	0.498	0.542	0.499	0.547	0.468	0.472	0.786	0.501	0.517	0.365	0.537	0.538	0.488	0.495
I10	0.455	0.491	0.455	0.428	0.461	0.497	0.494	0.466	0.487	0.772	0.535	0.393	0.530	0.518	0.484	0.534
I11	0.430	0.489	0.409	0.541	0.492	0.451	0.399	0.450	0.506	0.476	0.777	0.463	0.458	0.462	0.431	0.476
I12	0.361	0.473	0.438	0.440	0.503	0.567	0.455	0.468	0.510	0.492	0.325	0.777	0.458	0.444	0.490	0.449
I13	0.498	0.560	0.472	0.528	0.522	0.470	0.474	0.540	0.503	0.529	0.442	0.474	1.000	0.496	0.444	0.500
I14	0.436	0.536	0.510	0.556	0.568	0.526	0.511	0.496	0.528	0.546	0.518	0.493	0.543	0.747	0.463	0.488
I15	0.475	0.442	0.443	0.473	0.423	0.529	0.455	0.474	0.529	0.441	0.469	0.544	0.518	0.634	0.614	0.454
I16	0.520	0.579	0.533	0.598	0.512	0.509	0.515	0.513	0.592	0.549	0.499	0.548	0.517	0.524	0.485	0.635

Table 7. Overall total inter-correlation matrix

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16
I1	0.755	0.778	0.716	0.779	0.779	0.772	0.732	0.742	0.775	0.740	0.755	0.718	0.779	0.765	0.754	0.748
I2	0.805	0.890	0.805	0.878	0.865	0.859	0.814	0.826	0.866	0.825	0.837	0.806	0.869	0.855	0.842	0.835
I3	0.732	0.791	0.770	0.801	0.792	0.785	0.735	0.767	0.789	0.758	0.773	0.721	0.782	0.776	0.763	0.769
I4	0.828	0.883	0.825	0.928	0.892	0.886	0.835	0.859	0.890	0.851	0.866	0.821	0.885	0.871	0.866	0.866
I5	0.782	0.845	0.786	0.856	0.883	0.847	0.800	0.818	0.851	0.814	0.827	0.795	0.848	0.829	0.826	0.820
I6	0.719	0.790	0.734	0.803	0.798	0.827	0.750	0.768	0.798	0.745	0.772	0.724	0.792	0.765	0.777	0.768
I7	0.726	0.784	0.745	0.808	0.807	0.794	0.791	0.767	0.807	0.757	0.776	0.740	0.802	0.793	0.796	0.773
I8	0.731	0.800	0.742	0.805	0.802	0.803	0.750	0.807	0.806	0.751	0.785	0.721	0.793	0.776	0.778	0.799
I9	0.774	0.841	0.783	0.852	0.841	0.843	0.789	0.807	0.877	0.804	0.819	0.762	0.846	0.830	0.814	0.814
I10	0.747	0.809	0.753	0.811	0.809	0.810	0.767	0.780	0.815	0.810	0.795	0.741	0.818	0.801	0.788	0.793
I11	0.719	0.781	0.722	0.797	0.786	0.777	0.729	0.752	0.789	0.749	0.797	0.724	0.782	0.767	0.755	0.760
I12	0.703	0.772	0.719	0.778	0.780	0.785	0.730	0.748	0.783	0.744	0.736	0.755	0.775	0.758	0.756	0.750
I13	0.794	0.863	0.797	0.870	0.863	0.852	0.807	0.834	0.862	0.825	0.828	0.793	0.921	0.843	0.827	0.833
I14	0.786	0.859	0.802	0.873	0.868	0.859	0.812	0.828	0.865	0.827	0.838	0.795	0.865	0.873	0.830	0.832
I15	0.741	0.795	0.744	0.809	0.797	0.806	0.754	0.774	0.811	0.763	0.779	0.751	0.809	0.807	0.795	0.776
I16	0.810	0.880	0.819	0.893	0.876	0.872	0.826	0.845	0.888	0.842	0.850	0.815	0.877	0.861	0.847	0.864

Table 8. Causal inter-correlation among indicators.

	Asia and Oceania				Europe				North America				Latin America and Caribbean				Africa				Overall			
	α	β	$(\alpha + \beta)$	$(\alpha - \beta)$	α	β	$(\alpha + \beta)$	$(\alpha - \beta)$	α	β	$(\alpha + \beta)$	$(\alpha - \beta)$	α	β	$(\alpha + \beta)$	$(\alpha - \beta)$	α	β	$(\alpha + \beta)$	$(\alpha - \beta)$	α	β	$(\alpha + \beta)$	$(\alpha - \beta)$
I1	13.720	12.379	26.099	1.341	8.161	8.675	16.836	(0.514)	10.234	11.089	21.323	(0.855)	8.539	8.553	17.092	(0.014)	9.703	10.617	20.321	(0.914)	11.249	11.552	22.801	(0.303)
I2	12.682	14.227	26.910	(1.545)	8.273	9.646	17.918	(1.373)	9.743	11.070	20.813	(1.327)	8.189	9.054	17.242	(0.865)	9.140	10.685	19.825	(1.545)	10.768	12.261	23.029	(1.494)
I3	13.293	12.679	25.973	0.614	8.760	9.193	17.953	(0.433)	10.326	10.247	20.573	0.079	8.709	8.695	17.404	0.014	9.669	10.326	19.995	(0.657)	11.394	11.515	22.909	(0.122)
I4	13.429	13.894	27.324	(0.465)	9.061	9.633	18.695	(0.572)	10.300	10.967	21.267	(0.666)	8.726	8.967	17.692	(0.241)	9.577	10.231	19.808	(0.654)	11.477	12.048	23.525	(0.571)
I5	12.456	13.104	25.560	(0.648)	8.515	9.339	17.854	(0.825)	10.655	10.853	21.508	(0.199)	8.394	9.047	17.441	(0.653)	9.348	10.102	19.450	(0.754)	11.094	11.809	22.903	(0.715)
I6	13.374	13.744	27.118	(0.370)	8.500	9.454	17.954	(0.954)	10.833	11.151	21.985	(0.318)	8.733	8.600	17.333	0.133	9.399	10.367	19.767	(0.968)	11.403	11.941	23.343	(0.538)
I7	12.277	13.969	26.245	(1.692)	8.671	9.404	18.075	(0.733)	10.212	10.640	20.853	(0.428)	8.104	8.076	16.179	0.028	10.019	10.145	20.164	(0.126)	11.084	11.666	22.750	(0.583)
I8	13.743	13.232	26.975	0.511	9.931	9.713	19.644	0.218	11.063	10.559	21.622	0.504	9.346	8.731	18.077	0.615	9.861	10.488	20.349	(0.627)	12.149	11.866	24.016	0.283
I9	12.957	13.606	26.563	(0.648)	9.420	8.841	18.261	0.580	10.459	10.711	21.170	(0.252)	8.437	8.803	17.239	(0.366)	10.193	10.766	20.959	(0.572)	11.574	11.828	23.401	(0.254)
I10	13.389	13.759	27.147	(0.370)	9.419	8.629	18.048	0.790	11.013	9.797	20.810	1.216	8.719	7.991	16.710	0.729	10.232	10.889	21.121	(0.657)	11.854	11.410	23.264	0.444
I11	14.084	13.678	27.762	0.406	10.157	8.391	18.548	1.766	11.615	10.694	22.310	0.921	8.517	8.256	16.774	0.261	11.050	9.971	21.020	1.079	12.431	11.384	23.814	1.047
I12	12.346	12.111	24.457	0.234	9.045	9.154	18.199	(0.109)	11.062	10.074	21.136	0.988	8.611	8.588	17.199	0.023	10.390	9.330	19.720	1.060	11.598	11.128	22.726	0.470
I13	13.041	14.245	27.287	(1.204)	9.121	9.324	18.445	(0.203)	11.130	11.410	22.540	(0.280)	8.621	8.994	17.615	(0.373)	10.288	10.319	20.607	(0.030)	11.737	12.151	23.888	(0.414)
I14	14.350	12.878	27.228	1.472	9.943	9.569	19.512	0.374	9.982	11.200	21.182	(1.218)	9.222	8.457	17.679	0.765	11.163	9.767	20.929	1.396	12.277	11.665	23.941	0.612
I15	14.283	13.487	27.770	0.796	10.002	9.264	19.266	0.738	11.759	10.943	22.702	0.816	9.507	8.502	18.009	1.005	10.960	9.837	20.797	1.123	12.705	11.668	24.373	1.038
I16	12.692	13.003	25.695	(0.311)	9.509	9.901	19.410	(0.392)	11.242	10.108	21.350	1.135	8.246	8.487	16.733	(0.240)	10.107	10.366	20.473	(0.258)	11.633	11.687	23.320	(0.053)
I17	12.174	13.871	26.045	(1.697)	9.836	9.168	19.003	0.668	11.585	10.956	22.540	0.629	8.258	9.284	17.542	(1.026)	10.422	9.821	20.243	0.601	11.779	11.926	23.705	(0.148)
I18	13.968	13.559	27.527	0.410	8.868	9.190	18.058	(0.321)	11.797	10.188	21.985	1.609	8.771	9.343	18.114	(0.571)	10.612	10.288	20.899	0.324	12.081	11.837	23.918	0.245
I19	13.325	12.697	26.023	0.628	8.971	8.154	17.125	0.817	9.879	10.703	20.582	(0.824)	7.935	8.031	15.966	(0.096)	10.594	9.486	20.081	1.108	11.340	10.988	22.328	0.352
I20	13.474	12.827	26.301	0.647	8.712	9.006	17.718	(0.294)	10.305	10.932	21.237	(0.627)	8.482	8.359	16.842	0.123	10.204	9.566	19.770	0.638	11.462	11.403	22.865	0.059
I21	13.769	13.822	27.591	(0.053)	10.120	8.846	18.966	1.273	11.668	11.405	23.072	0.263	9.722	9.033	18.756	0.689	10.601	10.216	20.817	0.384	12.607	11.950	24.557	0.657
I22	14.314	12.370	26.683	1.944	8.341	8.843	17.183	(0.502)	9.793	10.959	20.753	(1.166)	9.712	9.653	19.365	0.059	9.970	9.921	19.891	0.049	11.696	11.708	23.404	(0.012)
Average			26.649				18.303				21.514				17.409				20.318				23.399	

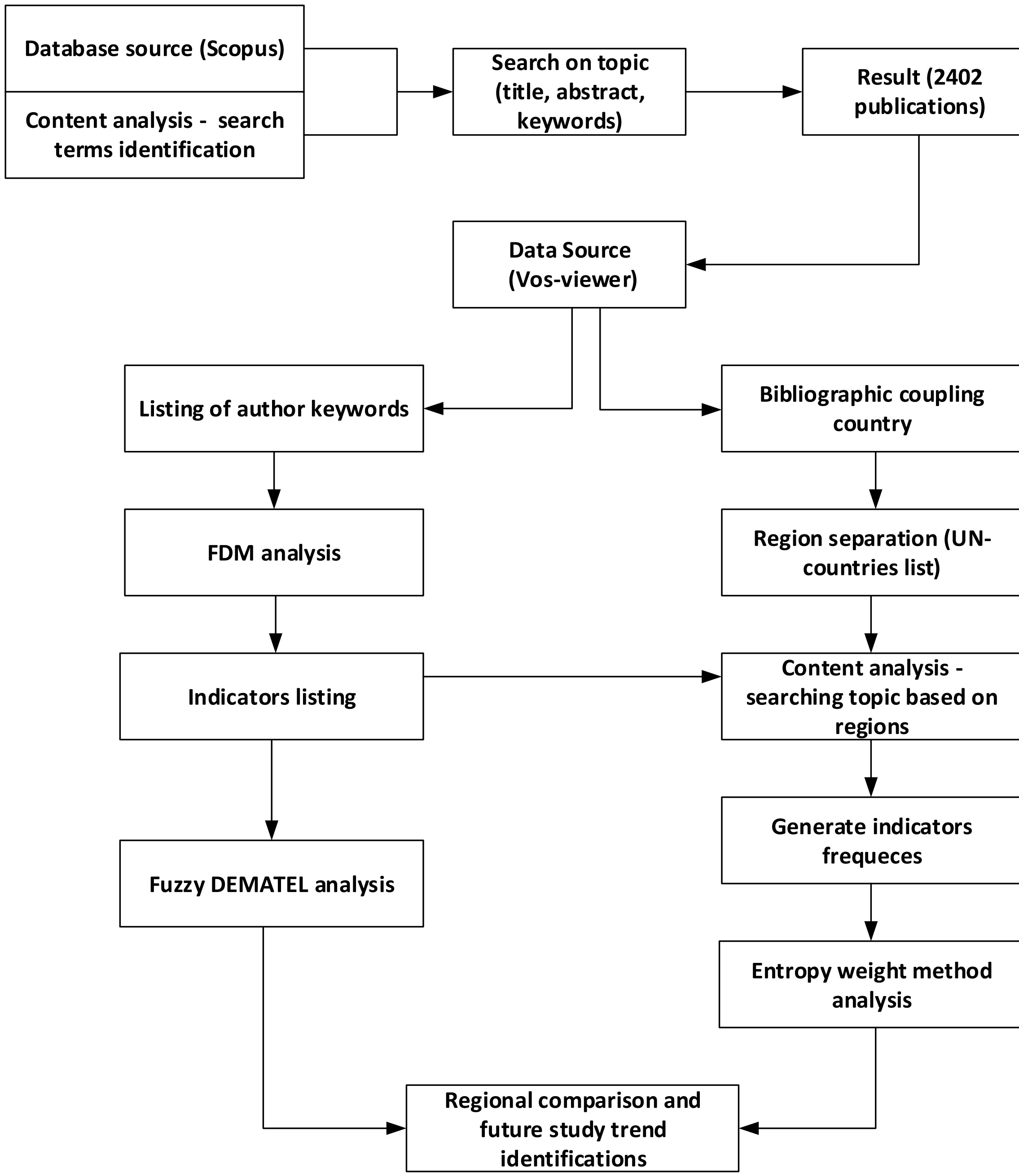
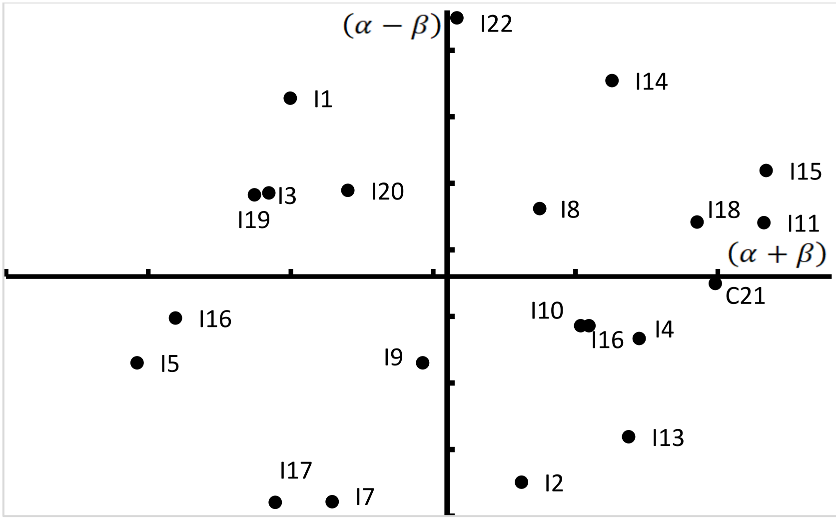
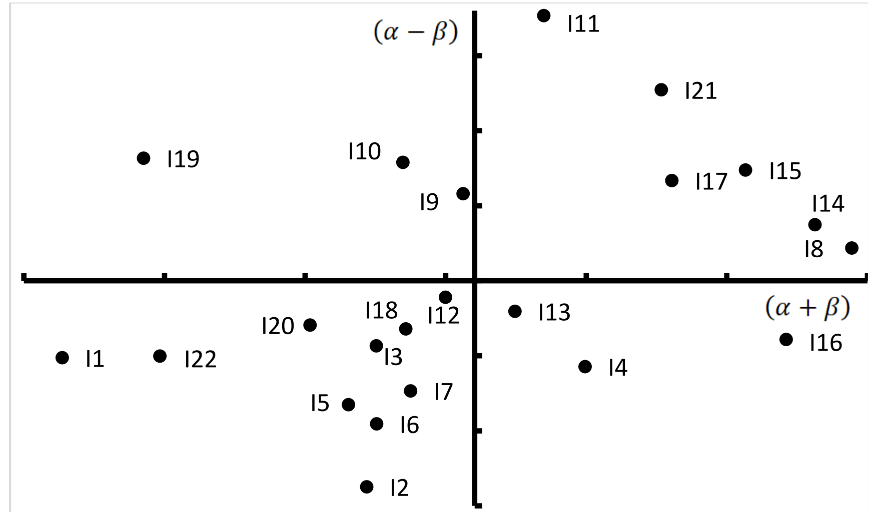


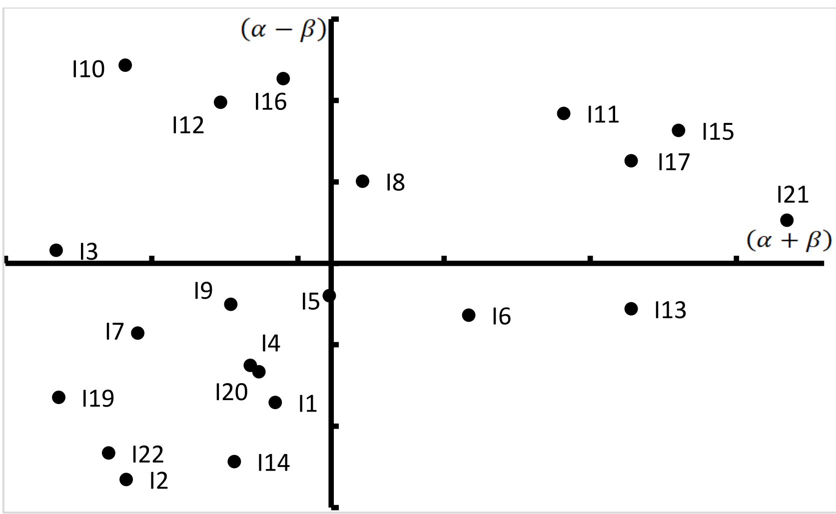
Figure 1. Analytical process



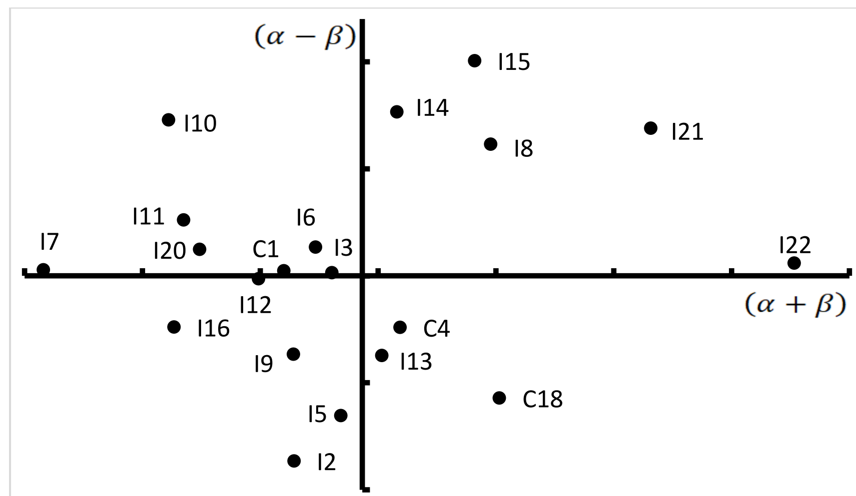
Asia and Oceania



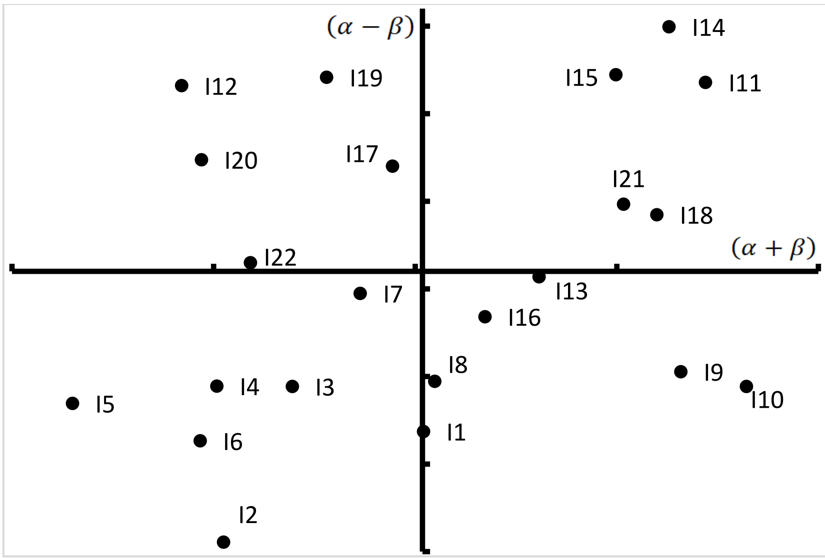
Europe



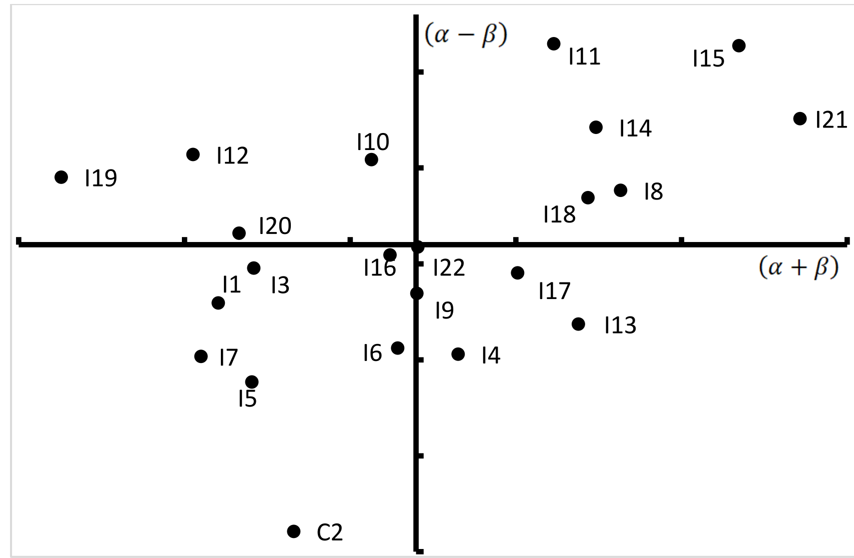
North America



Latin America and Caribbean



Africa



Overall benchmark

Figure 2. Causal inter-relationship of indicators among regions

Appendix A. Experts' demographic

Expert	Position	Education levels	Years of experience	Organization type (academia/practice)	Regional location
1	Professor	Ph.D.	10	Academia	Europe
2	Professor	Ph.D.	13	Academia	Asia and Oceania
3	Professor	Ph.D.	13	Academia	North America
4	Distinguished Professor	Ph. D	8	Academia	Europe
5	Professor	Ph.D.	8	Academia	Latin America and Caribbean
6	Distinguished Professor	Ph.D.	8	Academia	North America
7	Professor	Ph.D.	10	Academia	Africa
8	Professor	Ph.D.	13	Academia	Europe
9	Professor	Ph.D.	15	Academia	Latin America and Caribbean
10	Professor	Ph.D.	14	Academia	Asia and Oceania
11	Professor	Ph.D.	8	Academia	Europe
12	Distinguished Professor	Ph.D.	14	Academia	Asia and Oceania
13	Researcher & Section Chief (Professor)	Ph.D.	9	NGOs (Research center)	Latin America and Caribbean
14	Researcher & Section Chief (Professor)	Ph.D.	15	NGOs (Research center)	Africa
15	Researcher & Section Chief	Ph.D.	9	NGOs (Research center)	Asia and Oceania
16	Researcher	Master	11	NGOs (Research center)	Europe
17	Researcher	Master	9	NGOs (Research center)	North America
18	Director of Institute	Ph.D.	15	Government office	Africa
19	Deputy Director of Institute	Ph.D.	13	Government office	Asia and Oceania
20	Deputy Director of Institute	Ph.D.	13	Government office	Europe
21	Chief supply chain Officer	Ph.D.	10	Practices	Asia and Oceania
22	Chief Operating Officer	Ph.D.	14	Practices	Europe
23	Chief executive officer	Ph.D.	13	Practices	Asia and Oceania
24	Supply chain manager	Ph.D.	9	Practices	Africa
25	Supply chain manager	Master	15	Practices	Europe
26	Supply chain manager	Master	11	Practices	North America
27	Project manager	Master	8	Practices	Europe
28	Executive manager	Master	8	Practices	Asia and Oceania
29	Project manager	Master	8	Practices	Europe
30	Executive manager	Master	9	Practices	Asia and Oceania

The expert committee was approach thanks to the connections of Institute of Innovation and Circular Economy, Asia University, Taiwan.

Appendix B. Region search terms

Region	Search terms
Asia and Oceania	TITLE-ABS-KEY ("China" or "India" or "Australia" or "Iran" or "Japan" or "Hong Kong" or "Taiwan" or "Singapore" or "Malaysia" or "South Korea" or "New Zealand" or "Turkey" or "Pakistan" or "Thailand" or "Bangladesh" or "United Arab Emirates" or "Indonesia" or "Viet Nam" or "Philippines" or "Iraq" or "Qatar" or "Israel" or "Saudi Arabia" or "Jordan" or "Libyan Arab Jamahiriya" or "Sri Lanka" or "Fiji" or "Myanmar" or "Kuwait" or "Lebanon" or "Oman")
North America	TITLE-ABS-KEY (″Canada" or "United States")
Latin America and Caribbean	TITLE-ABS-KEY ("Brazil" or "Mexico" or "Chile" or "Argentina" or "Colombia" or "Peru" or "Costa Rica" or "El Salvador" or "Puerto Rico")
Europe	TITLE-ABS-KEY ("United Kingdom" or "Germany" or "France" or "Italy" or "Netherlands" or "Spain" or "Russian Federation" or "Sweden" or "Switzerland" or "Poland" or "Finland" or "Greece" or "Denmark" or "Belgium" or "Norway" or "Ireland" or "Portugal" or "Austria" or "Slovenia" or "Romania" or "Czech Republic" or "Hungary" or "Croatia" or "Luxembourg" or "Cyprus" or "Serbia" or "Lithuania" or "Iceland" or "Slovakia" or "Bosnia and Herzegovina" or "Georgia" or "Latvia" or "Malta" or "Montenegro")
Africa	TITLE-ABS-KEY ("South Africa" or "Morocco" or "Egypt" or "Ghana" or "Tunisia" or "Ethiopia" or "Algeria" or "Nigeria" or "Tanzania" or "Uganda" or "Angola" or "Congo" or "Cote D'Ivoire" or "Lesotho" or "Liberia")

Appendix C. List of co-occurrences of author keywords.

ID	Label	Weight <Occurrences>
1	Supply chain	277
2	Supply chain management	264
3	Risk management	153
4	Resilience	126
5	Supply chain risk management	96
6	Disruption	91
7	Supply chain resilience	88
8	Supply chain disruptions	72
9	Supply chain disruption	66
10	Disruption management	63
11	Supply disruption	57
12	Simulation	56
13	Sustainability	56
14	Game theory	53
15	Risk	46
16	Disruptions	41
17	Disruption risk	40
18	Logistics	40
19	Uncertainty	40

20	Supply chains	36
21	Supplier selection	34
22	Supply chain risk	32
23	Supply disruptions	31
24	System dynamics	30
25	Blockchain	29
26	Optimization	29
27	Supply chain design	29
28	Reliability	26
29	Robustness	26
30	Case study	25
31	Ripple effect	25
32	Supply chain coordination	24
33	Supply risk	24
34	Chaos	23
35	Demand disruption	23
36	Stochastic programming	23
37	China	22
38	Disruption risks	22
39	Complexity	21
40	Food safety	21
41	Risk analysis	21
42	Vulnerability	21
43	Automotive industry	20
44	Inventory	20
45	Supply chain network	20
46	Bullwhip effect	19
47	Closed-loop supply chain	19
48	Crisis management	19
49	Food security	19
50	Risk assessment	19
51	Supply chain dynamics	19
52	Supply chain network design	19
53	Innovation	18
54	Ambidexterity	17
55	Coordination	17
56	Robust optimization	17
57	Systematic literature review	17
58	Climate change	16
59	Collaboration	16
60	Pricing	16
61	Traceability	16
62	Agility	15

63	Flexibility	15
64	Humanitarian logistics	15
65	Recovery	15
66	Resilient supply chain	15
67	Additive manufacturing	14
68	Inventory management	14
69	RFID	14
70	Risk mitigation	14
71	Facility location	13
72	Management	13
73	Network design	13
74	Supply chain risks	13
75	Dual sourcing	12
76	Dual-channel	12
77	Information sharing	12
78	Outsourcing	12
79	Supply chain vulnerability	12
80	Sustainable supply chain	12
81	Bifurcation	11
82	Big data	11
83	Decision making	11
84	Disaster management	11
85	Financial crisis	11
86	Information technology	11
87	Inventory control	11
88	Literature review	11
89	Manufacturing	11
90	Procurement	11
91	Strategy	11
92	Supply chain performance	11
93	Sustainable development	11
94	Business continuity	10
95	Disaster	10
96	Disasters	10
97	Disruptive innovation	10
98	Energy security	10
99	Food supply chain	10
100	Global supply chain	10
101	Ism	10
102	Natural disasters	10
103	Operations management	10
104	Resiliency	10
105	Security	10

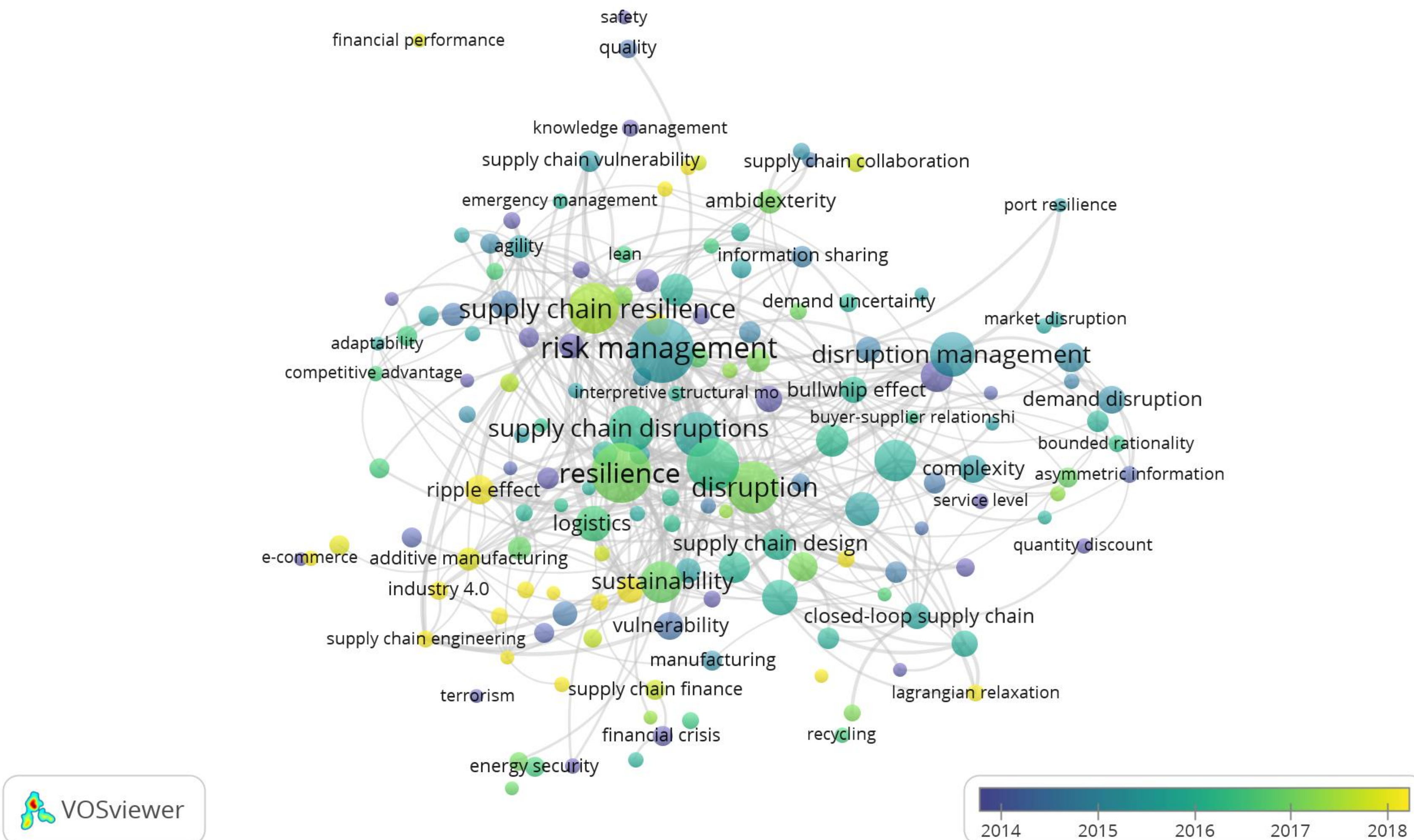
106	Supply chain finance	10
107	3d printing	9
108	Chaos theory	9
109	Conditional value-at-risk	9
110	Decision support	9
111	Demand uncertainty	9
112	Dematel	9
113	Governance	9
114	Graph theory	9
115	Industry 4.0	9
116	Modelling	9
117	Performance	9
118	Purchasing	9
119	Quality	9
120	Supply chain collaboration	9
121	Supply chain flexibility	9
122	Supply chain integration	9
123	Supply chain networks	9
124	Supply-chain management	9
125	Transportation	9
126	Asymmetric information	8
127	Australia	8
128	Blockchain technology	8
129	Blood supply chain	8
130	Contingency planning	8
131	Corporate social responsibility	8
132	Crisis	8
133	Critical infrastructure	8
134	Globalization	8
135	Knowledge management	8
136	Multi-agent system	8
137	Multi-objective optimization	8
138	Networks	8
139	Optimisation	8
140	Price competition	8
141	Production	8
142	Smart contracts	8
143	Supply chain engineering	8
144	Technology	8
145	Trust	8
146	Automotive	7
147	Bayesian network	7
148	Bounded rationality	7

149	Competition	7
150	Control	7
151	Data envelopment analysis	7
152	Dual-channel supply chain	7
153	Economic crisis	7
154	Exploration	7
155	Humanitarian supply chain	7
156	Lagrangian relaxation	7
157	Lean	7
158	Possibilistic programming	7
159	Remanufacturing	7
160	Stochastic demand	7
161	Sustainable supply chain management	7
162	Trade credit	7
163	Agent-based modeling	6
164	Agriculture	6
165	Brazil	6
166	Chaos control	6
167	Cloud computing	6
168	Competitive advantage	6
169	Coordination mechanism	6
170	Demand disruptions	6
171	Design	6
172	Disaster recovery	6
173	Dynamic capabilities	6
174	Dynamic programming	6
175	E-commerce	6
176	Emergency management	6
177	Empirical research	6
178	Entropy	6
179	Exploitation	6
180	Fuzzy ahp	6
181	Genetic algorithm	6
182	Green supply chain	6
183	Heuristics	6
184	India	6
185	Information asymmetry	6
186	Internet of things	6
187	Interpretive structural modelling	6
188	Japan	6
189	Machine learning	6
190	Market disruption	6
191	Mathematical modelling	6

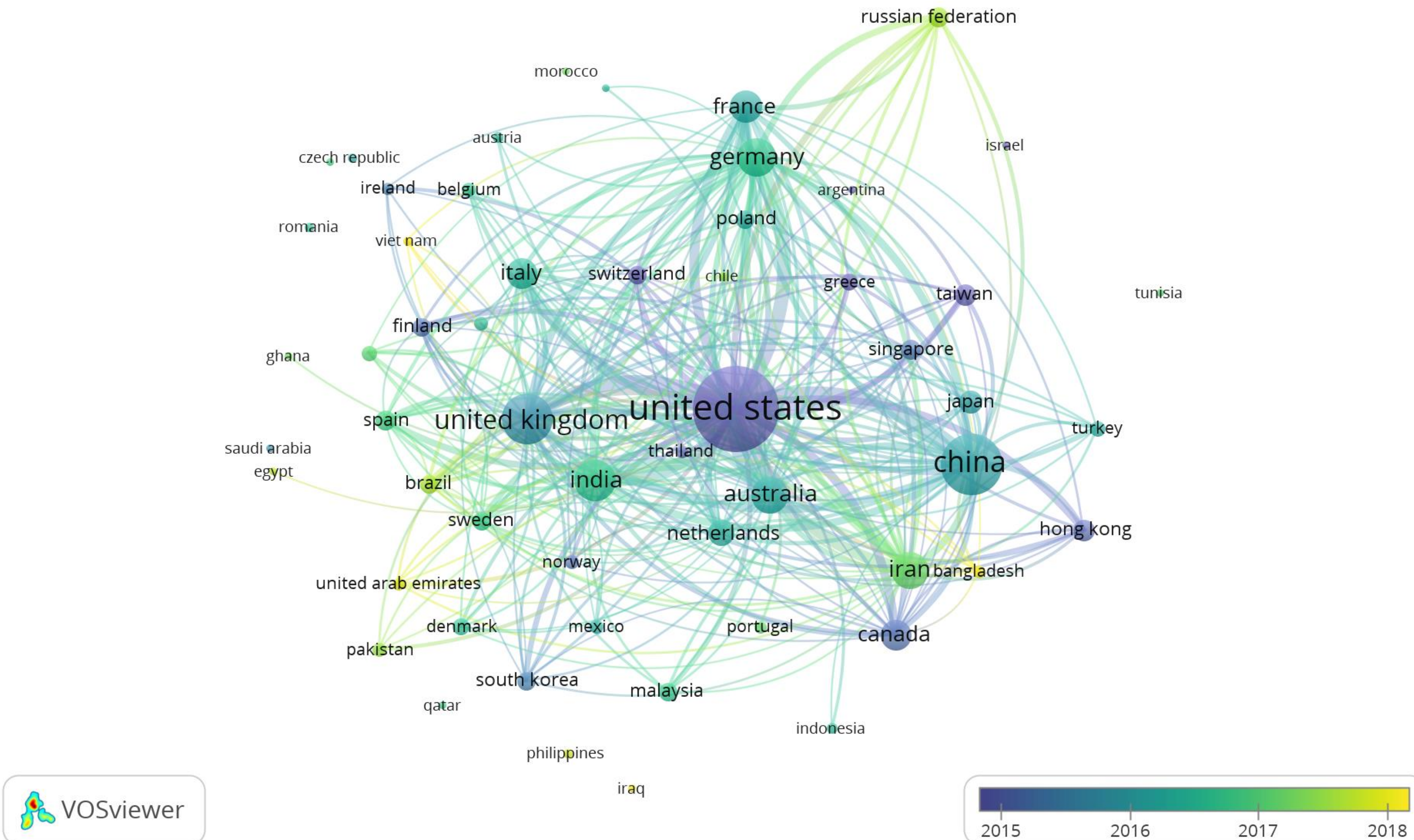
192	Mixed integer programming	6
193	Multi-agent systems	6
194	Production disruption	6
195	Quantity discount	6
196	Recycling	6
197	Revenue sharing contract	6
198	Risks	6
199	Scm	6
200	Scrm	6
201	Sensitivity analysis	6
202	Service level	6
203	Smes	6
204	Social responsibility	6
205	Stochastic mixed integer programming	6
206	Strategic planning	6
207	Structural equation modelling	6
208	Suppliers	6
209	Supply chain agility	6
210	Supply chain ambidexterity	6
211	Supply chain security	6
212	Supply networks	6
213	Survey	6
214	Thailand	6
215	Trade	6
216	Value chain	6
217	Variational inequalities	6
218	Adaptability	5
219	Ahp	5
220	Automobile industry	5
221	Backup supplier	5
222	Benders decomposition	5
223	Business model	5
224	Buyer-supplier relationships	5
225	Complex network	5
226	Disaster response	5
227	Disruptive technology	5
228	Distributed ledger technology	5
229	Distribution	5
230	Dual-sourcing	5
231	Dynamic capability	5
232	Emergency	5
233	Emergency response	5
234	Empirical study	5

235	Financial performance	5
236	Fmea	5
237	Food	5
238	Food system	5
239	Fuzzy logic	5
240	Global value chain	5
241	Goal programming	5
242	Indonesia	5
243	Information systems	5
244	Infrastructure	5
245	International trade	5
246	Life cycle assessment	5
247	Linear programming	5
248	Marketing	5
249	Mathematical programming	5
250	Metaheuristics	5
251	Mixed integer linear programming	5
252	Monte Carlo simulation	5
253	P-robustness	5
254	Pharmaceutical supply chain	5
255	Port resilience	5
256	Price game	5
257	Research	5
258	Resilient	5
259	Responsiveness	5
260	Reverse logistics	5
261	Risk propagation	5
262	Robust optimization	5
263	Safety	5
264	Safety stock	5
265	Scenario planning	5
266	Scenarios	5
267	Smart contract	5
268	Sourcing strategy	5
269	South Africa	5
270	Supply management	5
271	Systemic risk	5
272	Terrorism	5
273	Uncertain demand	5

Appendix D. Co-occurrence of author keywords by publication year - In particular, the SC, SC management, risk management, resilience, SC risk management, and disruption have the largest occurrences frequency and represented as the central keywords, which then have interrelationship with the others. The yellow nodes represent the latest occurring keywords, such as the financial performance, SC collaboration, industry 4.0, ripple effect, additive manufacturing, SC engineering, e-commerce, in recently explored from year of 2018.


safety
financial performance
quality
knowledge management
supply chain vulnerability
supply chain collaboration
emergency management
ambidexterity
port resilience
agility
lean
information sharing
demand uncertainty
supply chain resilience
market disruption
adaptability
risk management
disruption management
competitive advantage
interpretive structural mo
bullwhip effect
demand disruption
buyer-supplier relationshi
supply chain disruptions
bounded rationality
complexity
asymmetric information
resilience
disruption
ripple effect
service level
logistics
supply chain design
quantity discount
e-commerce
additive manufacturing
sustainability
industry 4.0
closed-loop supply chain
vulnerability
supply chain engineering
manufacturing
terrorism
supply chain finance
lagrangian relaxation
financial crisis
recycling
energy security
VOSviewer
2014
2015
2016
2017
2018

Appendix E. Bibliographic coupling of countries/territories by year - Bibliographic coupling by year is acquired reporting the most productive countries/territories is United State followed by the China and United Kingdom. The latest countries/territories listed in the field are Vietnam, United Arab Emirates, Bangladesh since 2018.


russian federation
morocco
france
israel
austria
germany
czech republic
ireland
belgium
argentina
poland
romania
viet nam
italy
switzerland
chile
greece
taiwan
tunisia
finland
singapore
ghana
united states
japan
spain
united kingdom
turkey
saudi arabia
thailand
china
egypt
india
brazil
australia
sweden
netherlands
hong kong
norway
iran
bangladesh
united arab emirates
denmark
mexico
portugal
canada
pakistan
south korea
malaysia
qatar
indonesia
philippines
iraq
VOSviewer
2015
2016
2017
2018

Appendix F. List of bibliographic coupling of productive countries/territories according to region (UN, 2019)

Asia and Oceania	Weight (Documents)	North America	Weight (Documents)	Latin America and Caribbean	Weight (Documents)	Europe	Weight (Documents)	Africa	Weight (Documents)
China	364	United States	714	Brazil	33	United Kingdom	250	South Africa	22
India	163	Canada	94	Mexico	19	Germany	143	Morocco	6
Australia	136			Chile	10	France	102	Egypt	5
Iran	129			Argentina	7	Italy	95	Ghana	5
Japan	53			Colombia	3	Netherlands	66	Tunisia	5
Hong Kong	46			Peru	2	Spain	43	Ethiopia	4
Taiwan	44			Costa Rica	1	Russian Federation	42	Algeria	3
Singapore	39			El Salvador	1	Sweden	35	Nigeria	3
Malaysia	35			Puerto Rico	1	Switzerland	35	Tanzania	2
South Korea	34					Poland	34	Uganda	2
New Zealand	25					Finland	33	Angola	1
Turkey	24					Greece	28	Congo	1
Pakistan	18					Denmark	27	Cote D'ivoire	1
Thailand	17					Belgium	22	Lesotho	1
Bangladesh	15					Norway	18	Liberia	1
United Arab Emirates	15					Ireland	17		
Indonesia	12					Portugal	15		
Viet Nam	10					Austria	13		
Philippines	8					Slovenia	11		
Iraq	6					Romania	9		
Qatar	6					Czech Republic	8		
Israel	5					Hungary	6		
Saudi Arabia	5					Croatia	5		
Jordan	4					Luxembourg	5		
Libyan Arab Jamahiriya	2					Cyprus	4		
Sri Lanka	2					Serbia	4		
Fiji	1					Lithuania	3		
Myanmar	1					Iceland	2		
Kuwait	1					Slovakia	2		
Lebanon	1					Bosnia And Herzegovina	1		
Oman	1					Georgia	1		
						Latvia	1		
						Malta	1		
						Montenegro	1		
Total	1222		808		77		1082		62

Appendix G. FDM indicators refined – round 1.

Indicators	l_b	u_b	D_b	Decision
Adaptability	(0.369)	0.869	0.342	**Accepted**
Additive Manufacturing	0.000	0.500	0.250	**Unaccepted**
Agility	0.000	0.500	0.250	**Unaccepted**
Ambidexterity	(0.025)	0.900	0.444	**Accepted**
Artificial Intelligence	0.000	0.500	0.250	**Unaccepted**
Asymmetric Information	0.000	0.500	0.250	**Unaccepted**
Backup Supplier	0.000	0.500	0.250	**Unaccepted**
Benders Decomposition	0.000	0.500	0.250	**Unaccepted**
Bifurcation	0.000	0.500	0.250	**Unaccepted**
Big Data	(0.348)	0.848	0.337	**Accepted**
Blockchain Technology	0.000	0.500	0.250	**Unaccepted**
Bounded Rationality	0.000	0.500	0.250	**Unaccepted**
Bullwhip Effect	0.000	0.500	0.250	**Unaccepted**
Business Continuity	(0.042)	0.917	0.448	**Accepted**
Buyer-Supplier Relationships	0.000	0.500	0.250	**Unaccepted**
Chaos Control	(0.046)	0.921	0.449	**Accepted**
Climate Change	0.000	0.500	0.250	**Unaccepted**
Closed-Loop Supply Chain	0.000	0.500	0.250	**Unaccepted**
Cloud Computing	0.000	0.500	0.250	**Unaccepted**
Collaboration	0.000	0.500	0.250	**Unaccepted**
Competition	0.000	0.500	0.250	**Unaccepted**
Competitive Advantage	(0.363)	0.863	0.341	**Accepted**
Complexity	0.000	0.500	0.250	**Unaccepted**
Conditional Value-At-Risk	0.000	0.500	0.250	**Unaccepted**
Contingency Planning	0.000	0.500	0.250	**Unaccepted**
Coordination	0.000	0.500	0.250	**Unaccepted**
Corporate Social Responsibility	(0.367)	0.867	0.342	**Accepted**
Crisis Management	(0.381)	0.881	0.345	**Accepted**
Critical Infrastructure	0.000	0.500	0.250	**Unaccepted**
Decision Making	0.000	0.500	0.250	**Unaccepted**
Demand Disruption	0.000	0.500	0.250	**Unaccepted**
Demand Uncertainty	(0.037)	0.912	0.447	**Accepted**
Design	0.000	0.500	0.250	**Unaccepted**
Disaster Management	(0.383)	0.883	0.346	**Accepted**
Disaster Recovery	0.000	0.500	0.250	**Unaccepted**
Disaster Response	0.000	0.500	0.250	**Unaccepted**
Disruption	0.000	0.500	0.250	**Unaccepted**
Disruption Management	0.000	0.500	0.250	**Unaccepted**
Disruptive Innovation	0.000	0.500	0.250	**Unaccepted**
Disruptive Technology	0.000	0.500	0.250	**Unaccepted**
Distributed Ledger Technology	0.000	0.500	0.250	**Unaccepted**
Distribution	0.000	0.500	0.250	**Unaccepted**
Dual Sourcing	0.000	0.500	0.250	**Unaccepted**
Dual-Channel	0.000	0.500	0.250	**Unaccepted**
Dynamic Capabilities	0.000	0.500	0.250	**Unaccepted**
E-Commerce	0.000	0.500	0.250	**Unaccepted**
Economic Crisis	0.000	0.500	0.250	**Unaccepted**
Emergency Management	0.000	0.500	0.250	**Unaccepted**
Emergency Response	(0.362)	0.862	0.340	**Accepted**
Energy Security	0.000	0.500	0.250	**Unaccepted**

Exploitation	0.000	0.500	0.250	**Unaccepted**
Exploration	0.000	0.500	0.250	**Unaccepted**
Facility Location	0.000	0.500	0.250	**Unaccepted**
Financial Crisis	(0.374)	0.874	0.344	**Accepted**
Financial Performance	0.000	0.500	0.250	**Unaccepted**
Flexibility	0.000	0.500	0.250	**Unaccepted**
Global Supply Chain	(0.055)	0.930	0.451	**Accepted**
Global Value Chain	0.000	0.500	0.250	**Unaccepted**
Globalization	0.000	0.500	0.250	**Unaccepted**
Governance	0.000	0.500	0.250	**Unaccepted**
Green Supply Chain	(0.332)	0.832	0.333	**Accepted**
Humanitarian Logistics	0.000	0.500	0.250	**Unaccepted**
Humanitarian Supply Chain	(0.429)	0.929	0.357	**Accepted**
Industry 4.0	0.000	0.500	0.250	**Unaccepted**
Information Asymmetry	0.000	0.500	0.250	**Unaccepted**
Information Sharing	0.000	0.500	0.250	**Unaccepted**
Information Systems	(0.411)	0.911	0.353	**Accepted**
Information Technology	0.000	0.500	0.250	**Unaccepted**
Infrastructure	0.000	0.500	0.250	**Unaccepted**
Innovation	0.000	0.500	0.250	**Unaccepted**
International Trade	0.000	0.500	0.250	**Unaccepted**
Internet Of Things	(0.020)	0.895	0.442	**Accepted**
Interpretive Structural Modelling	0.000	0.500	0.250	**Unaccepted**
Inventory	(0.353)	0.853	0.338	**Accepted**
Knowledge Management	(0.068)	0.943	0.454	**Accepted**
Lagrangian Relaxation	0.000	0.500	0.250	**Unaccepted**
Lean	(0.359)	0.859	0.340	**Accepted**
Life Cycle Assessment	0.000	0.500	0.250	**Unaccepted**
Logistics	0.000	0.500	0.250	**Unaccepted**
Machine Learning	0.000	0.500	0.250	**Unaccepted**
Manufacturing	0.000	0.500	0.250	**Unaccepted**
Market Disruption	0.000	0.500	0.250	**Unaccepted**
Marketing	0.000	0.500	0.250	**Unaccepted**
Multi-Agent System	0.000	0.500	0.250	**Unaccepted**
Natural Disasters	0.000	0.500	0.250	**Unaccepted**
Network Design	0.000	0.500	0.250	**Unaccepted**
Operations Management	(0.392)	0.892	0.348	**Accepted**
Optimization	0.000	0.500	0.250	**Unaccepted**
Outsourcing	(0.391)	0.891	0.348	**Accepted**
Performance	0.000	0.500	0.250	**Unaccepted**
Port Resilience	0.000	0.500	0.250	**Unaccepted**
Production Disruption	0.000	0.500	0.250	**Unaccepted**
Purchasing	0.000	0.500	0.250	**Unaccepted**
Quality	0.000	0.500	0.250	**Unaccepted**
Quantity Discount	0.000	0.500	0.250	**Unaccepted**
Recovery	0.012	0.863	0.434	**Accepted**
Recycling	0.000	0.500	0.250	**Unaccepted**
Reliability	0.000	0.500	0.250	**Unaccepted**
Remanufacturing	0.000	0.500	0.250	**Unaccepted**
Resilience	(0.403)	0.903	0.351	**Accepted**
Resilient Supply Chain	0.000	0.500	0.250	**Unaccepted**
Responsiveness	0.000	0.500	0.250	**Unaccepted**
Revenue Sharing Contract	0.000	0.500	0.250	**Unaccepted**

Reverse Logistics	(0.382)	0.882	0.345	**Accepted**
Ripple Effect	0.000	0.500	0.250	**Unaccepted**
Risk Management	0.000	0.500	0.250	**Unaccepted**
Safety	0.000	0.500	0.250	**Unaccepted**
Safety Stock	(0.419)	0.919	0.355	**Accepted**
Scenario Planning	0.000	0.500	0.250	**Unaccepted**
Security	(0.356)	0.856	0.339	**Accepted**
Service Level	0.000	0.500	0.250	**Unaccepted**
Smart Contracts	0.000	0.500	0.250	**Unaccepted**
Social Responsibility	(0.080)	0.955	0.458	**Accepted**
Sourcing Strategy	0.000	0.500	0.250	**Unaccepted**
Strategic Planning	0.000	0.500	0.250	**Unaccepted**
Supplier Selection	0.000	0.500	0.250	**Unaccepted**
Supply Chain Agility	(0.383)	0.883	0.346	**Accepted**
Supply Chain Ambidexterity	(0.389)	0.889	0.347	**Accepted**
Supply Chain Collaboration	(0.370)	0.870	0.342	**Accepted**
Supply Chain Coordination	(0.392)	0.892	0.348	**Accepted**
Supply Chain Design	(0.375)	0.875	0.344	**Accepted**
Supply Chain Disruption	0.000	0.500	0.250	**Unaccepted**
Supply Chain Disruptions	(0.398)	0.898	0.349	**Accepted**
Supply Chain Dynamics	(0.405)	0.905	0.351	**Accepted**
Supply Chain Engineering	(0.325)	0.825	0.331	**Accepted**
Supply Chain Finance	(0.400)	0.900	0.350	**Accepted**
Supply Chain Flexibility	(0.319)	0.819	0.330	**Accepted**
Supply Chain Integration	(0.032)	0.907	0.446	**Accepted**
Supply Chain Network Design	(0.345)	0.845	0.336	**Accepted**
Supply Chain Performance	0.000	0.500	0.250	**Unaccepted**
Supply Chain Resilience	(0.402)	0.902	0.350	**Accepted**
Supply Chain Risk	0.000	0.500	0.250	**Unaccepted**
Supply Chain Risk Management	(0.068)	0.943	0.454	**Accepted**
Supply Chain Risks	0.000	0.500	0.250	**Unaccepted**
Supply Chain Security	0.000	0.500	0.250	**Unaccepted**
Supply Chain Vulnerability	(0.398)	0.898	0.349	**Accepted**
Supply Disruption	0.000	0.500	0.250	**Unaccepted**
Supply Disruptions	0.000	0.500	0.250	**Unaccepted**
Sustainability	(0.371)	0.871	0.343	**Accepted**
Sustainable Development	0.000	0.500	0.250	**Unaccepted**
Sustainable Supply Chain	0.000	0.500	0.250	**Unaccepted**
Sustainable Supply Chain Management	0.000	0.500	0.250	**Unaccepted**
System Dynamics	(0.064)	0.939	0.453	**Accepted**
Technology	(0.083)	0.958	0.458	**Accepted**
Terrorism	0.000	0.500	0.250	**Unaccepted**
Traceability	(0.430)	0.930	0.358	**Accepted**
Trade	0.000	0.500	0.250	**Unaccepted**
Trade Credit	0.000	0.500	0.250	**Unaccepted**
Transportation	(0.422)	0.922	0.356	**Accepted**
Trust	0.000	0.500	0.250	**Unaccepted**
Uncertain Demand	0.000	0.500	0.250	**Unaccepted**
Uncertainty	(0.023)	0.898	0.443	**Accepted**
Value Chain	0.000	0.500	0.250	**Unaccepted**
Variational Inequalities	0.000	0.500	0.250	**Unaccepted**
Vulnerability	(0.295)	0.795	0.324	**Accepted**

Threshold	0.290

Appendix H. FDM indicators refined – round 2.

Indicators	l_b	u_b	D_b	Decision
Adaptability	(0.368)	0.868	0.342	**Accepted**
Ambidexterity	0.000	0.500	0.250	**Unaccepted**
Big data	0.000	0.500	0.250	**Unaccepted**
Business continuity	0.000	0.500	0.250	**Unaccepted**
Chaos control	(0.064)	0.939	0.453	**Accepted**
Competitive advantage	(0.350)	0.850	0.338	**Accepted**
Corporate social responsibility	0.000	0.500	0.250	**Unaccepted**
Crisis management	0.000	0.500	0.250	**Unaccepted**
Demand uncertainty	0.000	0.500	0.250	**Unaccepted**
Disaster management	(0.056)	0.931	0.452	**Accepted**
Emergency response	0.000	0.500	0.250	**Unaccepted**
Financial crisis	0.000	0.500	0.250	**Unaccepted**
Global supply chain	0.000	0.500	0.250	**Unaccepted**
Green supply chain	(0.019)	0.894	0.442	**Accepted**
Humanitarian supply chain	0.000	0.500	0.250	**Unaccepted**
Information systems	0.000	0.500	0.250	**Unaccepted**
Internet of things	0.000	0.500	0.250	**Unaccepted**
Inventory	0.000	0.500	0.250	**Unaccepted**
Knowledge management	0.000	0.500	0.250	**Unaccepted**
Lean	(0.366)	0.866	0.342	**Accepted**
Operations management	0.000	0.500	0.250	**Unaccepted**
Outsourcing	0.000	0.500	0.250	**Unaccepted**
Recovery	0.000	0.500	0.250	**Unaccepted**
Resilience	0.000	0.500	0.250	**Unaccepted**
Reverse logistics	0.000	0.500	0.250	**Unaccepted**
Safety stock	0.000	0.500	0.250	**Unaccepted**
Security	0.000	0.500	0.250	**Unaccepted**
Social responsibility	(0.415)	0.915	0.354	**Accepted**
Supply chain agility	(0.361)	0.861	0.340	**Accepted**
Supply chain ambidexterity	(0.375)	0.875	0.344	**Accepted**
Supply chain collaboration	(0.003)	0.878	0.438	**Accepted**
Supply chain coordination	(0.394)	0.894	0.348	**Accepted**
Supply chain design	0.000	0.500	0.250	**Unaccepted**
Supply chain disruptions	(0.338)	0.838	0.335	**Accepted**
Supply chain dynamics	(0.091)	0.966	0.460	**Accepted**
Supply chain engineering	0.000	0.500	0.250	**Unaccepted**

Supply chain finance	(0.356)	0.856	0.339	**Accepted**
Supply chain flexibility	(0.356)	0.856	0.339	**Accepted**
Supply chain integration	(0.042)	0.917	0.448	**Accepted**
Supply chain network design	(0.375)	0.875	0.344	**Accepted**
Supply chain resilience	(0.369)	0.869	0.342	**Accepted**
Supply chain risk management	(0.419)	0.919	0.355	**Accepted**
Supply chain vulnerability	(0.356)	0.856	0.339	**Accepted**
Sustainability	(0.003)	0.878	0.438	**Accepted**
System dynamics	0.000	0.500	0.250	**Unaccepted**
Technology	0.000	0.500	0.250	**Unaccepted**
Traceability	0.000	0.500	0.250	**Unaccepted**
Transportation	0.000	0.500	0.250	**Unaccepted**
Uncertainty	(0.398)	0.898	0.349	**Accepted**
Vulnerability	0.000	0.500	0.250	**Unaccepted**
Threshold			**0.306**	

Appendix I. FDM round 1 questionnaire.

Please evaluate the performance/importance level of each indicator below to Sustainable supply chain management towards disruption and organizational ambidexterity by marking the blank						
	Indicators	Extreme	Demonstrated	Strong	Moderate	Equal
1	Adaptability					
2	Additive Manufacturing					
3	Agility					
4	Ambidexterity					
5	Artificial Intelligence					
6	Asymmetric Information					
7	Backup Supplier					
8	Benders Decomposition					
9	Bifurcation					
10	Big Data					
11	Blockchain Technology					
12	Bounded Rationality					
13	Bullwhip Effect					
14	Business Continuity					
15	Buyer-Supplier Relationships					
16	Chaos Control					
17	Climate Change					
18	Closed-Loop Supply Chain					
19	Cloud Computing					

20	Collaboration					
21	Competition					
22	Competitive Advantage					
23	Complexity					
24	Conditional Value-At-Risk					
25	Contingency Planning					
26	Coordination					
27	Corporate Social Responsibility					
28	Crisis Management					
29	Critical Infrastructure					
30	Decision Making					
31	Demand Disruption					
32	Demand Uncertainty					
33	Design					
34	Disaster Management					
35	Disaster Recovery					
36	Disaster Response					
37	Disruption					
38	Disruption Management					
39	Disruptive Innovation					
40	Disruptive Technology					
41	Distributed Ledger Technology					
42	Distribution					
43	Dual Sourcing					
44	Dual-Channel					
45	Dynamic Capabilities					
46	E-Commerce					
47	Economic Crisis					
48	Emergency Management					
49	Emergency Response					
50	Energy Security					
51	Exploitation					
52	Exploration					
53	Facility Location					
54	Financial Crisis					
55	Financial Performance					
56	Flexibility					
57	Global Supply Chain					
58	Global Value Chain					
59	Globalization					
60	Governance					

61	Green Supply Chain					
62	Humanitarian Logistics					
63	Humanitarian Supply Chain					
64	Industry 4.0					
65	Information Asymmetry					
66	Information Sharing					
67	Information Systems					
68	Information Technology					
69	Infrastructure					
70	Innovation					
71	International Trade					
72	Internet of Things					
73	Interpretive Structural Modelling					
74	Inventory					
75	Knowledge Management					
76	Lagrangian Relaxation					
77	Lean					
78	Life Cycle Assessment					
79	Logistics					
80	Machine Learning					
81	Manufacturing					
82	Market Disruption					
83	Marketing					
84	Multi-Agent System					
85	Natural Disasters					
86	Network Design					
87	Operations Management					
88	Optimization					
89	Outsourcing					
90	Performance					
91	Port Resilience					
92	Production Disruption					
93	Purchasing					
94	Quality					
95	Quantity Discount					
96	Recovery					
97	Recycling					
98	Reliability					
99	Remanufacturing					
100	Resilience					
101	Resilient Supply Chain					

102	Responsiveness					
103	Revenue Sharing Contract					
104	Reverse Logistics					
105	Ripple Effect					
106	Risk Management					
107	Safety					
108	Safety Stock					
109	Scenario Planning					
110	Security					
111	Service Level					
112	Smart Contracts					
113	Social Responsibility					
114	Sourcing Strategy					
115	Strategic Planning					
116	Supplier Selection					
117	Supply Chain Agility					
118	Supply Chain Ambidexterity					
119	Supply Chain Collaboration					
120	Supply Chain Coordination					
121	Supply Chain Design					
122	Supply Chain Disruption					
123	Supply Chain Disruptions					
124	Supply Chain Dynamics					
125	Supply Chain Engineering					
126	Supply Chain Finance					
127	Supply Chain Flexibility					
128	Supply Chain Integration					
129	Supply Chain Network Design					
130	Supply Chain Performance					
131	Supply Chain Resilience					
132	Supply Chain Risk					
133	Supply Chain Risk Management					
134	Supply Chain Risks					
135	Supply Chain Security					
136	Supply Chain Vulnerability					
137	Supply Disruption					
138	Supply Disruptions					
139	Sustainability					
140	Sustainable Development					
141	Sustainable Supply Chain					
142	Sustainable Supply Chain Management					

143	System Dynamics					
144	Technology					
145	Terrorism					
146	Traceability					
147	Trade					
148	Trade Credit					
149	Transportation					
150	Trust					
151	Uncertain Demand					
152	Uncertainty					
153	Value Chain					
154	Variational Inequalities					
155	Vulnerability					

Appendix J. FDM round 2 questionnaire.

Please evaluate the performance/importance level of each indicator below to Sustainable supply chain management towards disruption and organizational ambidexterity by marking the blank (in this round you can change your evaluation compared with the previous round)						
	Indicators	Extreme	Demonstrated	Strong	Moderate	Equal
1	Adaptability					
2	Ambidexterity					
3	Big data					
4	Business continuity					
5	Chaos control					
6	Competitive advantage					
7	Corporate social responsibility					
8	Crisis management					
9	Demand uncertainty					
10	Disaster management					
11	Emergency response					
12	Financial crisis					
13	Global supply chain					
14	Green supply chain					
15	Humanitarian supply chain					
16	Information systems					
17	Internet of things					
18	Inventory					
19	Knowledge management					
20	Lean					
21	Operations management					
22	Outsourcing					

23	Recovery					
24	Resilience					
25	Reverse logistics					
26	Safety stock					
27	Security					
28	Social responsibility					
29	Supply chain agility					
30	Supply chain ambidexterity					
31	Supply chain collaboration					
32	Supply chain coordination					
33	Supply chain design					
34	Supply chain disruptions					
35	Supply chain dynamics					
36	Supply chain engineering					
37	Supply chain finance					
38	Supply chain flexibility					
39	Supply chain integration					
40	Supply chain network design					
41	Supply chain resilience					
42	Supply chain risk management					
43	Supply chain vulnerability					
44	Sustainability					
45	System dynamics					
46	Technology					
47	Traceability					
48	Transportation					
49	Uncertainty					
50	Vulnerability					

Appendix K. Fuzzy DEMATEL questionnaire.

The assessment of indicators addresses in a pair-wise comparison evaluation. Each indicator listed in the first column in the left of the table will show Influence degree to the attribute listed on the first row of the table.

Please place a number that match with your evaluation (as the scale from 1 to 5 refer the Influence degree of indicator from "very low" to "very high") that presented in the below box.

Influence degree	Scale
very high (vh)	5
high (h)	4
medium (m)	3
low (l)	2
very low (vl)	1

Please place a number that match with your evaluation according to your geographical regions

		I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18	I19	I20	I21	I22
I1	Adaptability																						
I2	Chaos control																						
I3	Competitive advantage																						
I4	Disaster management																						
I5	Green supply chain																						
I6	Lean																						
I7	Social responsibility																						
I8	Supply chain agility																						
I9	Supply chain ambidexterity																						
I10	Supply chain collaboration																						
I11	Supply chain coordination																						
I12	Supply chain disruptions																						
I13	Supply chain dynamics																						
I14	Supply chain finance																						
I15	Supply chain flexibility																						

I16	Supply chain integration																						
I17	Supply chain network design																						
I18	Supply chain resilience																						
I19	Supply chain risk management																						
I20	Supply chain vulnerability																						
I21	Sustainability																						
I22	Uncertainty																						