Original Article: The convergence between sustainability and reliability in the design of supply chain: a systematic literature review

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ABSTRACT

The convergence between sustainability and reliability as one of the emerging opportunities in the design and management of supply chains was investigated in this research study. In the form of a research agenda, this review classifies 65 articles on the intersection of sustainability, reliability, and supply chain network design published in Web of Science and Scopus databases from 2011 to August 2022. Eventually, the selected articles helped to identify four emerging sustainability phenomena with the combination of reliability (i.e., profitable and reliable, responsible and reliable, green and reliable, and sustainable and reliable). While reviewing the literature, it was realized that the sustainability and reliability research streams had been developed separately despite the publication of many articles and scientific contributions. From a sustainability perspective, minimizing costs and greenhouse gas emissions are the main objectives, while social aspects are hardly considered.

Introduction

Reliability is an opportunity for a scientific initiative and the development of a new paradigm in the planning and management of scarce resources. This requires an approach compatible with sustainability science [1]. A reliable product from an environmental perspective is also a sustainable product. Because a reliable product with a long useful life can save resources by preventing the production of new products in the initial steps, reducing logistics costs, and reducing spare parts [2]. Reliability as a fundamental factor in describing the optimal combination of maintenance strategies to accurately predict failure in a system contributes to more efficient use of all resources [3]. A maintenance policy based on equipment reliability can significantly reduce energy consumption and related greenhouse gas

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emissions [4]. As a similar result, Yılmaz *et al.* (2021) recently stated in their study's computational analysis that the change in the level of reliability, in addition to the change in the total cost, also changes the levels of carbon emissions in the entire reverse supply chain [5]. Basu and Lee (2022) confirmed that reliability practices act as a catalyst for sustainability outcomes, indicating enormous potential for integration [6]. In addition, Ghobakhloo *et al.* (2022) found that only when both sustainability and reliability paradigms are implemented simultaneously they reveal their full potential and generate more benefits than when they are implemented separately, and it is synergy [7].

Reliable and secure infrastructure is critical to the sustainability of developed societies. After a natural disaster, delivering humanitarian aid to the affected population as quickly as possible can minimize mortality [8]. Mistakes in packaging and consumption of contaminated pharmaceuticals (such as the Heparin disaster) have killed many patients so far. The adverse effects of such disturbances (such as the coronavirus epidemic) on sustainable supply chains are bigger and faster [9,10]. Suppose a system cannot recover from disturbances. In that case, it cannot recover its initial quality and, therefore, cannot achieve its economic, environmental, and social goals [11]. In such a situation, industrial managers should adopt policies that make the supply chain sustainable, highly resistant, and reliable [12]. Therefore, supply chain activities should be coordinated and managed so that high-quality products and reliable services are available to customers at minimum cost [13]. Improving delivery reliability and ensuring customer satisfaction is a lever to facilitate supply chain sustainability [14]. Recently, Johnson (2023) categorized mathematical models and called the model in which the passage of time affects the response of the system the non-sustainable model [15]. Amirian *et al.* (2022a) considered the issue of designing a closed-loop supply chain network in a multi-objective, multi-product, multi-period, and multi-faceted manner. Solving their model has spent almost a lot of time due to its nonlinearity [16].

In general, the intersection between sustainability and reliability and its relationship with business continuity management has become an essential issue in academia and industry [17]. This integration can be seen as a complex but relevant criterion in supply chain network design. From the perspective of system optimization, design decisions in sustainability, reliability, and supply chain are related, and the overall problem can be seen as a simultaneous optimization problem in these three design areas. With this goal in mind, a category for the articles is presented after a systematic selection of studies at the intersection of sustainability and reliability in supply chain network design. The developed classification for the literature is able to identify research gaps and provide promising research proposals. In this way, we hope to contribute to the existing literature by establishing the foundations of a rapidly growing concept.

Methodology

A systematic literature review designs a process that is repeatable, scientific, and transparent [18]. A systematic literature review has recently become a standard method for conducting a literature review on sustainable supply chains [19]. The strict selection criteria, analysis, and reporting methods used in this approach enable the combination of extensive knowledge in existing studies to generate new knowledge [20]. Most literature reviews provide a new and integrated perspective on related yet fragmented topics. In addition, literature reviews support the presentation of analytical frameworks for a specific topic (such as sustainability-reliability in supply chain network design) or the introduction of a new research topic [21]. Based on this, to increase methodological accuracy and create new insights from existing knowledge, a systematic literature review method has been adopted for this study. For this goal, this question should be answered How has the sustainability and reliability literature evolved in the application of supply chain network design?

In this article, the information available in Scopus and Web of Science databases has been used as comprehensive research sources to identify documents [22]. The first published paper in empirical research is from 2011, so 2011 is the starting year. The data collection phase was conducted on August 1, 2022, which is considered the end. In addition to the period of publication (between 2011 and August 2022), the search was refined based on the type of document (research article and conference paper) and language (English). The search terms were in the title, abstract, and keywords. The combination of keywords and the search method are presented in Table 1.

Table 1: Keywords and their combinations for searching

Search string	Combination of keywords	Number of articles
First string	"supply chain" and "network" and (sustainability or three dimensions of sustainability) and (reliability or operation without failure)	209
Second string	"Supply chain design" and (sustainability or three dimensions of sustainability) and (reliability or failure-free operation)	155

Articles that contain any of the selected keywords in their title, abstract, and keywords and are not part of review articles are included in the evaluation process. Exclusion criteria included unrelated disciplines (e.g., medicine) and articles that did not consider network design, stability, or reliability. These articles are considered out of scope. Two reviewers (one of the authors) analyzed these results independently to reduce bias [23]. Any disagreements were discussed until a consensus was reached. Based on the mentioned entry criteria, the review eliminated 121 and 93 articles through title and abstract analysis, respectively. The remaining 91 articles were subjected to full-text analysis, which identified 38 additional articles. Finally, the snowball method (as an inclusion criterion) was applied to the sources used in the final 53 articles [24]. Implementing this method added 12 articles to the list (these articles had more helpful insight into the research topic). As a result, 65 articles were selected for analysis.

Classification analysis

In this section, the selected articles are classified based on the level of attention to sustainability and reliability in the supply chain network design. Table 2 specifies the basis of this classification. In the following, the identified literature is summarized in this classification. During the description of these studies, the research gap and the direction of future research are determined.

Table 2: Literature classification

The supply chain paradigm	The three pillars of sustainability			Reliability	Number of articles
	Social	Environmental	Economical		
Profitable and reliable	×	×	✓	✓	23
Responsible and reliable	✓	×	✓	✓	6
Green and reliable	×	✓	✓	✓	15
Sustainable and reliable	✓	✓	✓	✓	21

Turning to the main question of the research, the extent of the expansion of the four paradigms in the supply chain design literature is determined by the number of articles and the time of the emergence of the paradigm. In this way, Figure 1 shows the time of emergence and degree of complexity of four supply chain paradigms. The measure of the complexity of paradigms is the number of sustainability dimensions considered in the network design. The size of the circles also represents the number of articles in each paradigm. The profitable and reliable paradigm, as the most traditional paradigm, only includes an economic dimension of sustainability. Therefore, it has a minor complexity. However, the most publication is related to this paradigm [25,26]. This number can be justified considering the age of this paradigm. Only after 2014 did researchers publish articles analyzing the links between the social domain of the supply chain and reliability. The smallest circle with six articles related to the second historical paradigm, the responsible and reliable supply chain. This paradigm's lack of sufficient development can attract future research attention as a research gap. Four of the six articles devoted to this subject area are related to reverse logistics and closed-loop supply chains to create systems where waste disposal processes are minimized by exploiting reuse, repair, remanufacturing, and recycling processes.

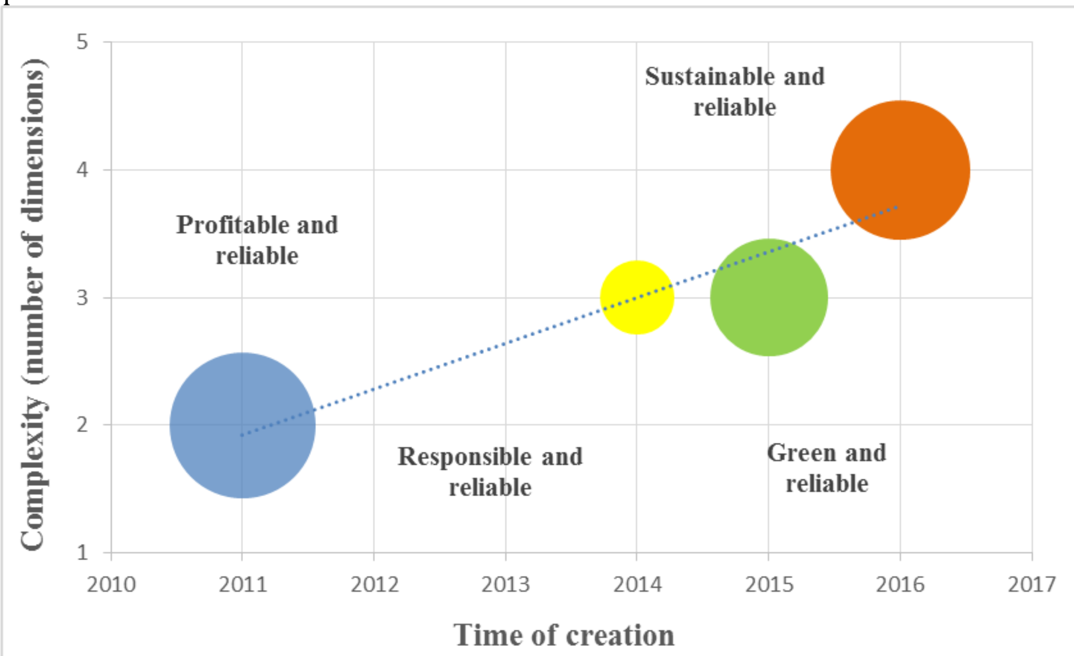

Figure 1: Time of creation and degree of complexity for paradigms.

The green and reliable paradigm assume the environmental dimension of sustainability as the dominant perspective in sustainability. The environmental perspective has appeared more prominently than the social aspect in the reviewed literature. The green and reliable paradigm, as the third paradigm, accounts for 24% of the total number of sources [27-29]. In comparison, the responsible and reliable paradigm has only 10% of the sources in the third category [30-32]. The difference between these two classes of literature is consistent with the results of previous review studies in the field of supply chain sustainability. For example, Moreno-Camacho *et al*. (2019), after identifying the sustainability evaluation indicators used in 113 articles on supply chain network design from 2015 to 2018, stated that 96.5% of the articles included environmental issues and 45.2% percent focused on social issues [33]. Saeed and Kersten (2020), to evaluate organizations and their performance related to the sustainability of their supply chains, based on a study in the literature, identified 68 indicators of sustainability performance. Of these, 47% are from the environmental dimension, 31% from the social dimension, and 22% from the economic dimension [34]. However, the green and reliable supply chain paradigm emerged one year after the responsible and reliable supply chain paradigm. Both paradigms are at the second level of complexity by considering the two dimensions of sustainability (economic and environmental) and (economic and social), respectively. In addition, the green and reliable supply chain paradigm are older (one year) than the sustainable and reliable supply chain paradigm. However, its circle size is 0.25 smaller than the circle of the sustainable and reliable supply chain paradigm. This visual distinction shows the researchers' interest in integrating the three pillars of sustainability with reliability in the design of the supply chain network. Therefore, the highest level of complexity belongs to the sustainable and reliable emerging paradigm.

The field of sustainability-reliability includes 21 articles [13,16,35]. As of 2015, the paradigms of profitable and reliable, responsible and reliable, and green and reliable are visible in the supply chain network design literature with a weak trend. After 2015, sustainable and reliable supply chain network design began to emerge as a new paradigm, and other subject areas such as environmental resilience measures [36], resilience strategies [37], Resilience measures at least [35], which are closely related to the concept of reliability, were identified. As empirical evidence shows, high production speed leads to more defects and frequent breakdowns of production machinery [38]. New supply chain paradigms, such as the automated terminal [39], avoid the risks and waste associated with loading and unloading and real-time communication by improving production reliability, workplace safety, decision-making processes, Risk management and accountability to stakeholders at micro-organizational and value network levels contribute to sustainable development goals [40].

Conclusion

Considering a 12-year period (from 2011 to 2022), the present review covers a broad spectrum of the evolution of the sustainable and reliable supply chain paradigm. Understanding this paradigm requires additional research effort to test the structures, concepts, and theories that emerge in the historical course of this paradigm's emergence. The result of this effort is to provide a common ground for future research. By classifying 65 reference articles under sustainability perspectives, the present study provides a global framework of the current literature on sustainability-reliability integration. The presented framework, by separating four research clusters from each other evolution process of a sustainable and reliable supply chain paradigm is showing. Pursuing multiple sustainability objectives simultaneously potentially slows decision-making. Integrating reliability with sustainability is expected to reduce more of decision-making speed. However, centralized decision-making structures may moderate this relationship. However, the structure of most supply chains in today's markets is decentralized. Therefore, it can be said that the importance of decision-making speed for managers in the face of stability and disruption risks is one of the determining factors of the supply chain's centralized structure/decentralized structure. Analyzing this relationship can open an interesting opportunity for researchers.

Appendix

Table 3 in this sector shows the characteristics of the particular articles while providing a more accurate subject classification.

Table 3: Summary of research background

Paradigm	Author (year)	Network structure		Dimensions of sustainability			Levels of reliability		
		Open-loop	Closed-loop	Economical	Environmental	Social	Facilitate (Node)	Path (Arc)	Chain (Network)
Profitable and reliable	Hsu and Li (2011)	✓		✓			✓		
	Jabbarzadeh et al (2011)	✓		✓			✓		
	Madadi et al (2012)	✓		✓			✓		
	Khalifehzadeh et al (2015)	✓		✓				✓	
	Pasandideh et al (2015)	✓		✓			✓		
	Kamalahmadi and Mellat-Parast (2016)	✓		✓			✓		
	Torabi et al (2016)		✓	✓			✓		

	Ghomi-Avili et al (2017)		✓	✓			✓		
	Poudel et al (2018)	✓		✓			✓		
	Rohaninejad et al (2018)	✓		✓			✓		
	Salimi and Vahdani (2018)	✓		✓					✓
	Fazli-Khalaf et al (2018)	✓		✓			✓		
	Pavlov et al (2019)	✓		✓			✓		
	Hatefi et al (2019)	✓		✓			✓		
	Diabat et al (2019)	✓		✓			✓		
	Gholami et al (2019)	✓		✓			✓		
	Prakash et al (2020)		✓	✓					✓
	Haghjoo et al (2020)	✓		✓			✓		
	Samuel et al (2021)		✓	✓			✓		
	Khezerlou et al (2021)	✓		✓					✓
	Li et al (2022)	✓		✓				✓	
	Goudarzi et al (2022)		✓	✓					✓
	Zhou et al (2022)	✓		✓			✓		
Responsible and reliable	Mohammadi et al (2014)	✓		✓		✓	✓		
	Hamidieh et al (2017)		✓	✓		✓	✓		
	Hamidieh and Fazli-Khalaf (2017)		✓	✓		✓	✓		
	Fazli-Khalaf and Hamidieh (2017)		✓	✓		✓		✓	
	Hamidieh et al (2018)		✓	✓		✓	✓		
	Ardakani et al (2020)	✓		✓		✓			✓
Green and reliable	Ghayebloo et al (2015)		✓	✓	✓		✓		
	Fazli-Khalaf et al (2017)		✓	✓	✓		✓		
	Rahmani and Mahoodian (2017)	✓		✓	✓		✓		
	Fakhrzad and Goodarzian (2019)		✓	✓	✓		✓		
	Li et al (2019)	✓		✓	✓		✓		
	Marchi et al (2019)	✓		✓	✓		✓		
	Kaur and Singh (2019)	✓		✓	✓		✓		
	Abir et al (2020)		✓	✓	✓		✓		
	Mousavi-Ahranjani et al (2020)	✓		✓	✓		✓		
	Kabadurmus and Erdogan (2020)	✓		✓	✓		✓		
	Nosrati and Khamseh (2020)	✓		✓	✓				✓
	Wang et al (2020)	✓		✓	✓		✓		
	Abdolazimi et al (2020)		✓	✓	✓		✓		
	Yılmaz et al (2021)	✓		✓	✓			✓	
	Foong and Ng (2022)	✓		✓	✓		✓		
Sustainable and reliable	Fahimnia and Jabbarzadeh (2016)	✓		✓	✓	✓	✓		
	Zahiri et al (2017)	✓		✓	✓	✓	✓		
	Fattahi and Govindan (2018)	✓		✓	✓	✓	✓		
	Jabbarzadeh et al (2018)	✓		✓	✓	✓	✓		
	Zare Mehrjerdi and Lotfi (2019)		✓	✓	✓	✓	✓		
	Fazli-Khalaf et al (2020)	✓		✓	✓	✓	✓		
	Hosseini-Motlagh et al (2020)	✓		✓	✓	✓			✓
	Tirkolaee et al (2020)	✓		✓	✓	✓	✓		
	Tsao and Thanh (2020)	✓		✓	✓	✓		✓	
	Fazli-Khalaf et al (2021)		✓	✓	✓	✓	✓		
	Lotfi et al (2021)		✓	✓	✓	✓	✓		
	Zare Mehrjerdi and Shafiee (2021)		✓	✓	✓	✓	✓		
	Sadeghi et al (2021)	✓		✓	✓	✓	✓		
	Govindan and Gholizadeh (2021)	✓		✓	✓	✓	✓		
	Sazvar et al (2021)	✓		✓	✓	✓	✓		
	Goodarzian et al (2022)	✓		✓	✓	✓	✓		
	Akbari-Kasgari et al (2022)		✓	✓	✓	✓	✓		
	Amirian et al (2022a)		✓	✓	✓	✓			✓
	Salehi et al (2022)	✓		✓	✓	✓	✓		
	Taleizadeh et al (2022)		✓	✓	✓	✓	✓		
	Mohammadi and Nikzad (2022)		✓	✓	✓	✓	✓		

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