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Sustainable supply chain coordination: extant literature, trends, and future research directions

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Abstract
Sustainability has garnered significant attention from both academia and practice in recent decades. While the term "sustainable supply chain" (SSC) was uncommon in the early 2000s, there has been a surge in literature on SSC since 2010. This study aims to review critical concepts of sustainable supply chain coordination (SSCC) problems, identify research gaps, and highlight main research streams and future directions. Recent studies in SSCC can be categorized into five areas: (1) consumer environmental awareness, (2) corporate social responsibility, (3) carbon legislation, (4) coordination of reverse and closed-loop supply chains, and (5) governmental intervention in SSCC. The existing literature is analyzed and evaluated based on the triple bottom line of sustainability to provide a comprehensive critical survey of the problem. While the existing literature primarily focuses on the economic aspect of sustainability, current review of SSCC drivers and barriers reveals an increasing trend in the application of different coordination mechanisms and contracts. Such strategies aim to enhance supply chain profitability while promoting environmental and social performance improvement. This review presents an up-to-date overview of recent progresses, emerging trends, and research gaps in the area of SSCC. Finally, it explores future research avenues by focusing on emerging topics, novel theoretical approaches, and multidisciplinary perspectives.

Keywords Supply chain management · Coordination · Sustainability · Consumer behavior · Corporate social responsibility · Contract design

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1 Introduction

In today's highly competitive business landscape, sustainability has become a mandatory requirement due to the growing awareness among consumers. Additionally, the increasing regulations imposed by authorities have further accelerated this shift. For many years, cost reduction was the sole priority and ultimate goal for profit-oriented corporations. However, the paradigm is shifting as businesses recognize that sustainability not only aligns with ethical considerations but also makes sound business sense. Nevertheless, this trend has garnered significant attention and importance in recent years, primarily due to the alarming volume of greenhouse gas emissions (Sana, 2023) that poses a critical threat to the sustainability of our planet. Environmentalists have taken the lead in raising awareness about the complex reality of climate change and its consequences (Hajat et al., 2014) and there remains much to research on the impact of climate change on supply chain management (SCM) (Yun & Ülkü, 2023). These efforts have prompted industries to pay closer attention to their carbon footprint and identify opportunities for carbon reduction within their systems. In 2009, a committee consisting of 186 corporations, collectively possessing assets worth at least 13 trillion US dollars, signed an agreement proposing guidelines and strategies to address global warming (Modak et al., 2016c). Subsequently, industrialized and developed countries established the Paris Agreement in 2016 to address climate change (Rogelj et al., 2016). Operating in accordance with environmental preservation policies (Kroes et al., 2012) has become a strategic pillar in the new business world order. While researchers have examined the cost benefits of eco-friendly products, it has become evident that this new business paradigm often involves costly production processes (Deif, 2011; Liu et al., 2012; Sana, 2020). In recent years, the significance of sustainability has been emphasized through the United Nations' Sustainable Development Goals (Cai & Choi, 2020). These goals aim to draw the attention of governments, activists, and academia to the immediate requirements of achieving a sustainable environment (Cf, 2015).

Sustainability, in the context of SCM literature, refers to the ability to utilize resources without compromising their availability for future generations. This concept becomes crucial due to the conflicting interests between business owners and sustainability goals (Sana, 2022a). The aim of this survey is to investigate the existing efforts in addressing the problem of sustainable supply chain coordination (SSCC) which is about aligning supply chain (SC) activities to promote environmental, social, and economic sustainability. While a substantial body of research has delved into the concept of sustainable supply chain network design (SSCND) problems (Eskandarpour et al., 2015; Nagurney & Nagurney, 2010; Ramudhin et al., 2010; Seuring, 2013; Seuring & Müller, 2008), SSCC problem remains relatively underexplored. However, it is clear that the absence of effective coordination mechanisms and the presence of conflicting objectives among various SC members constitute significant hurdles to achieving sustainability in SCs (Heydari et al., 2022). Furthermore, it is widely acknowledged that coordination among SC members is an indispensable driver for value creation in SSCs (Raimondo et al., 2021). Therefore, this research study is dedicated to shedding light on the intricate dynamics of coordination mechanisms within SSCs. This investigation not only seeks to unravel the complexities associated with SSCC but also aims to analyze the intricate interactions among the foundational pillars of sustainability. The triple bottom line (TBL) outline, encompassing the social, environmental, and economic dimensions of sustainability, has proven to be an effective approach for analyzing various aspects of this issue. The interactions among these three pillars have given rise to five primary research areas in the current survey: (1) consumers' environmental awareness (CEA), (2)

corporate social responsibility (CSR), (3) carbon legislation and regulations, (4) reverse supply chain (RSC) and closed-loop supply chain (CLSC), and finally, (5) governmental interventions. These research areas have been explored through a wide range of studies, including investigations into emission abatement investments, carbon taxes (Metcalf, 2009), carbon cap-and-trade policies (Du et al., 2015a; Zhang & Xu, 2013), consumer preferences for low-carbon products (Du et al., 2015b; Ji et al., 2017), and business responsibilities toward the society and environment (Modak et al., 2019a; Nematollahi et al., 2018) in both RCSs/CLSCs as well as forward SCs.

This review aims to address the following key questions:

(i) What are the primary motivations behind coordinating an SSC?
(ii) Which metrics are used to evaluate the performance of a coordinated SSC?
(iii) What trends are emerging and declining in the field of SSCC?
(iv) What notable research gaps exist in the study of SSCC?

The rest of this paper is structured as follows. The related early reviews are outlined in Sect. 2. Section 3 covers the taxonomy of SSCC literature and the procedure for selecting, classifying, and categorizing the key reviewed papers. The methodological approaches are investigated in Sect. 4. In Sect. 5, a research gap analysis and future research directions on SSCC are presented. Finally, Sect. 6 concludes the paper.

2 Early SSC reviews

Table 1 provides a summary of relevant literature reviews on SSC issues. Some reviews, such as those by Rebs et al. (2019), Manavalan and Jayakrishna (2019), Mardani et al. (2020), Akbari and McClelland (2020), and Mishra et al. (2023) focus on specific aspects of SSCC. An early review conducted by Gold et al. (2010) examined the competition advantages derived from sustainable business practices using content analysis. This analysis identified a paradigm shift from firm-level to supply chain-level competition and concluded that the complexity of inter-firm capabilities prevents easy imitation by rival companies. Sarkis et al. (2010) investigated the role of social sustainability in reverse logistics as an emerging topic. More recently, Pimenta et al. (2021) discussed the social and environmental pillars of sustainability and identified vital success factors. Their bibliometric and thematic analyses highlighted a significant gap in addressing the interactions among these factors. By reviewing and building upon the existing literature, this research seeks to enhance our understanding of the SSCC problem and addresses the research gaps identified by previous reviews.

In line with previous literature reviews, the present study employs four key criteria for assessing the literature:

1. *Focus area of the study* The study aims to determine the specific aspects of sustainability that have received greater emphasis in the literature.
2. *Publication date* The focus is on relatively recent publications to ensure that the study captures the most up-to-date research in the field.
3. *Methodology* The study outlines the methodological approaches employed in the literature, providing insights into the research methods used to investigate SSCC.
4. *Outcomes* The study identifies research gaps, offers managerial insights, and suggests future research directions, contributing to the advancement of knowledge in the field of SSCC.

By employing these four baselines, the study aims to provide a comprehensive analysis of the literature, highlighting the focal areas, methodological aspects, and outcomes of previous

Table 1 SSC review papers (The abbreviations are given in the Appendix)

Authors	Sustainability viewpoint	Findings
Srivastava (2007)	GSCM criteria	Providing one of the first reviews on the GSCM Classifying major influential areas of the SC problem Presenting an informative illustration of the GSC criteria
Seuring and Müller (2008)	Economic and Environmental	Conducting a literature review on SSCM Identifying RSC as a key business process within the GSC framework Evaluating the economic aspect of literature
Carter and Liane Easton (2011)	TBL	Conducting a systematic review on SSCM over a 20-year period Identifying an evolutionary trend on social and environmental issues of SSCM; through CSR perspective; to the convergence of perspectives toward sustainability and the emergence of the theoretical framework of SSCM
Sarkis et al. (2011)	Adoption, diffusion, and outcomes of GSCM practices	Pointing out the growing trend on the GSCM issue Utilizing nine broad organizational theories, categorizes the existing literature to provide comprehension of both current positions of the GSCM problem and future research opportunities/avenues Extracting important research questions in the GSCM area
Ahi and Searcy (2013)	TBL and other key characteristics for business sustainability	Analyzing published definitions of GSCM and SSCM and concluding that GSCM is an integral part of SSC, focusing on sustainability's environmental aspects

research. This approach enables the identification of research gaps and offers valuable insights for practitioners as well as future researchers.

Numerous studies have examined different dimensions of sustainability, including economic, environmental, and social aspects. As an early review on green supply chains (GSC), Srivastava (2007) conducted categorizing the literature based on problem context and influential areas of SCs. Over time, researchers and practitioners have expanded the scope of GSC and explored the interactions between sustainability and supply chain performance. However, there remains a scarcity of literature reviews specifically focusing on coordination efforts in SSCs.

Table 1 (continued)

Authors	Sustainability viewpoint	Findings
Seuring (2013)	Environmental and Social	Identifying a large difference in the number of quantitative studies between forward and RSCs/CLSCs addressing sustainability Pointing out the lack of proper studies addressing the social side of sustainability along with the limited amount of empirical research
Brandenburg et al. (2014)	Environmental and Social	Reviewing quantitative models in environmental and social aspects of sustainability Pointing out the lack of realistic models in addressing uncertainty Highlighting the evolving trend of sustainability concepts Emphasizing the ignorance of social issues in SSCM and GSCM problems
Gurtu et al. (2015)	Utilizing 13 different common keywords	Analyzing keywords used in the peer-reviewed literature on GSCM based on 629 papers from 2007 to 2012 Identifying the increasing trend in using "green supply chains" and "sustainable supply chains" terms over the decreasing usage of "reverse logistics."
Ansari and Kant (2017)	Considering a vast range of properties of research quality from methodology to enablers and barriers	Presenting knowledge gaps and possible research avenues based on the content analysis of 286 chosen articles Identifying momentum in some studies based on SSCM over the past few years Suggesting research opportunities on quantitative modeling and uncertainty considerations in the SSCM area
Rajeev et al. (2017)	TBL	Surveying 1068 papers published from 2000 to 2015 Identifying the lack of proper studies addressing all three pillars of sustainability Pointing out the ignorance of social issues over the economic aspects

Table 1 (continued)

Authors	Sustainability viewpoint	Findings
Reefke and Sundaram (2017)	TBL + Governance, Risk, Compliance, and Performance	Providing knowledge on underlying dynamics and themes of the sustainability issue in SCs Identifying key elements in the research agenda for SSCM Conducting a Delphi study with SSC experts to analyze the existing literature Classifying SSCM studies regarding SC planning, execution, coordination, and collaboration Structuring possible research avenues based on TBL
Panigrahi et al. (2018)	TBL	Investigating the theoretical perspectives in SSCM to understand current research activities and future potential Focusing on the perspectives of governance mechanisms for successful implementation of SSCM practices Identifying the trends and relevant research gaps to define the potential areas for future research
Ghosh et al., (2020a, 2020b)	Carbon footprint	Adopting a bibliometric approach on Scopus to select 37 papers Identifying the research gap in social development and social responsibility aspects of carbon-related studies
Khan et al. (2021)	TBL	Investigating the emerging trends in the area of SSCM over 2004–2019 Categorizing the existing literature based on drivers and barriers Clarifying the need for efficient algorithms and advanced economic modeling at the macro-level

Existing literature reviews have examined various aspects of sustainable supply chain management (SSCM), such as quantitative models (Brandenburg et al., 2014), supply chain network design problems (Eskandarpour et al., 2015), and theoretical dynamics (Touboulic & Walker, 2015). These reviews indicate a significant potential for further investigation in the field of SSC, particularly in terms of developing quantitative models. Furthermore, it is evident that the social and environmental pillars of sustainability have received less attention compared to the economic pillar. The current review aims to explore studies that address sustainability issues within the supply chain coordination (SCC) literature to identify

opportunities for advancement. Other literature reviews focusing on different aspects of SSC can be found in Diabat and Govindan (2011) and Tseng et al. (2019).

3 Taxonomy of SSCC literature

In this study, SSCC literature is categorized and examined based on the drivers and incentives that encourage supply chain owners to adopt sustainable production and planning processes. The classification of drivers and incentives is aligned with existing literature in the field. Figure 1 provides a visual representation of the motivational drivers of SSCC.

The classification in Fig. 1 aligns with the TBL of sustainability, which encompasses environmental, economic, and social considerations (Elkington, 1998). The study further explores the interactions among these three pillars to provide a comprehensive analysis of the literature. By organizing the literature based on drivers and incentives, this study aims to provide insights into the factors that motivate supply chain actors to engage in sustainable practices. Understanding these drivers and incentives is crucial for promoting SSCC and achieving the goals of TBL.

3.1 Financial plus social

3.1.1 CSR considerations in SSCC

CSR includes a wide range of topics including human rights, corporate governance, health and safety, environmental impact, working conditions, and contribution to economic development. In the early 2000s, CSR gained significant attention from stakeholders in SCs. There is substantial evidence showcasing the impact of CSR on the reputation of organizations and businesses. Incidents like the collapse of the *Rana Plaza building* in Bangladesh (Yardley, 2013) and the *horsemeat scandal* in the UK (Yamoah & Yawson, 2014) have compelled SCs to consider the social and environmental consequences of their operations. Many well-known companies have faced accusations of employee workplace violations (Amaeshi et al., 2008). However, with the rapid growth of consumers' social awareness (CSA), the tide has shifted

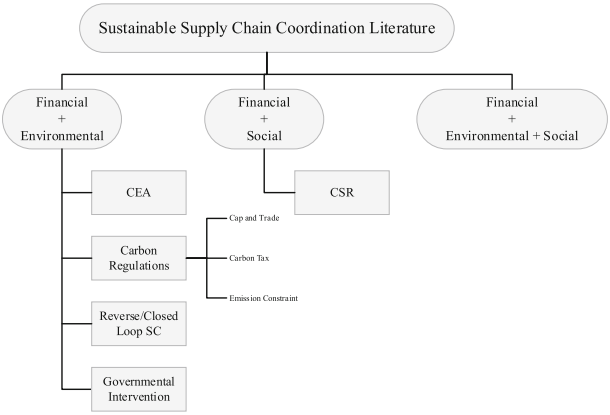

Fig. 1 Classification of the SSCC literature

in favor of CSR. Authorities have introduced codes of conduct to regulate business practices. Prominent global brands and corporations such as Adidas, Nike, Alcoa, Walmart, PepsiCo, Ford Motor Company, Exelon, PG&E, Starbucks, Johnson & Johnson, General Electric, and GAP have made significant investments in CSR activities (Modak et al., 2016a, 2016b). For example, GAP has implemented changes in working conditions across its more than 3000 manufacturing sites (Merrick, 2004). By 2016, three-quarters of China's top 200 companies had reported their CSR activities (Liu et al., 2019a). The growing emphasis on CSR reflects the increasing recognition of the social impact of business operations. Companies are actively taking steps to address these issues and incorporate responsible practices into their supply chain management. This shift is driven by both consumer demand and regulatory measures, as stakeholders place greater importance on sustainable and ethical business practices.

Although contemporary studies on CSR in SCs are generally simplistic, more sophisticated models are gradually developed to tackle complex real-world problems in this area. Hsueh and Chang (2008) were among the pioneers who integrated CSR into the context of SCC. Subsequent advancements in supply chain structures, optimizing performance, and determining optimal levels of CSR activities for SCs occurred in the work of Hsueh (2014) and Hsueh (2015). The concept of CSR is often used interchangeably with *corporate sustainability*, although there are distinctions between the two (Hsueh, 2014). This lack of a precise definition of CSR has led to challenges in its practical implementation and manifestation, particularly from an academic perspective. Dahlsrud (2008) conducted an analysis of different interpretations of CSR and catagorized them into five sub-classes: economic, environmental, social, stockholders, and voluntariness. While qualitative studies analyzing various dimensions of CSR abound, the development of quantitative models specifically addressing CSR activities in SCs, particularly in the context of SSCC, is relatively scarce. This highlights a research gap in the SSCC literature, where qualitative models for analyzing CSR activities are not extensively explored.

The existing literature predominantly focuses on two-echelon SCs with deterministic demand, which does not fully capture the complexities of real-world problems. In reality, demand exhibits high levels of uncertainty, and the channel structure can be more intricate than the two-echelon structure commonly studied, such as Manufacturer-Retailer or Supplier-Retailer relationships. Other relationships, such as Supplier-Manufacturer or Government-Manufacturer, are also relevant (Liu et al., 2019b; Raza, 2018). Moreover, game structures in the context of CSR have received limited attention in the existing literature, particularly in addressing the imbalance of power between retailers and manufacturers (Ma et al., 2017). While some studies have examined the influence of CSR efforts on consumers' price sensitivity, many assume a constant coefficient, neglecting the potential variability and dynamics of consumer behavior (Heydari & Mosanna, 2018; Jamali & Rasti-Barzoki, 2018; Panda & Modak, 2016). The need for further investigation into price competition in SSCs and its relationship with CSR-related factors is evident. Although there are some studies that analyze price competition in the context of vertical integration (Modak et al., 2016a; Sabbaghnia & Taleizadeh, 2021), the exploration of cross-price sensitivity coefficients remains limited in the literature (Seyedhosseini et al., 2019). This highlights a research gap and the need for further research to understand the dynamics of price competition and its implications for SSCs.

Table 2 provides an overview of the different perspectives and approaches to CSR in the existing literature. Two main approaches are identified: (1) CSR investment and (2) elevated consumer surplus. The first approach focuses on CSR as an investment, while the second approach emphasizes the positive impact of CSR on consumer satisfaction and welfare. Some studies consider CSR investments directly as a decision variable, allowing firms to allocate

Table 2 Different perceptions of CSR in the literature (for the meanings of abbreviations, see Appendix)

#	Authors	CSR coefficient/ Decision variable	CSR cost/ Profit term	CSR exhibition
1	Ni et al. (2010)	CSR investment	Quadratic	–
2	Goering (2012)	Consumer surplus	Quadratic	–
3	Hsueh (2014)	CSR investment	Linear	–
4	Panda (2014)	Consumer surplus	Quadratic	–
5	Panda et al. (2015)	Consumer surplus	Quadratic	–
6	Modak et al. (2016a)	Consumer surplus	Quadratic	–
7	Panda and Modak (2016)	Consumer surplus	Quadratic	–
8	Ma et al. (2017)	CSR investment	Quadratic	–
9	Nematollahi et al. (2017)	CSR investment	Linear	–
10	Panda et al. (2017)	Consumer surplus	Quadratic	–
11	Heydari and Mosanna (2018)	CSR investment	Linear	Cause-related marketing
12	Liu et al. (2018)	CSR investment	Quadratic	–
13	Nematollahi et al. (2018)	CSR effort	–	Pharmaceutical SC
14	Raza (2018)	CSR investment	Square root	–
15	Liu et al. (2019b)	CSR investment	Quadratic	–
16	Hosseini-Motlagh et al. (2019b)	CSR investment	Linear	–
17	Hou et al. (2019)	CSR investment	Quadratic	–
18	Liu et al. (2019a)	CSR investment	Quadratic	–
19	Liu et al. (2019c)	CSR investment	Linear	Tourism SC
20	Modak et al. (2019a)	CSR investment	Square root	Social Work Donation
21	Seyedhosseini et al. (2019)	CSR effort	Exponential decay	–
22	Phan et al. (2019)	CSR effort	Quadratic	–
23	Seyedhosseini et al. (2019)	CSR investment	Linear	–
24	Tian et al. (2020)	CSR investment	Quadratic	–
25	Jokar and Hosseini-Motlagh (2020)	CSR investment	Linear	–
26	Mahdiraji et al. (2020)	CSR effort	Power expression	Forced labor
27	Johari and Hosseini-Motlagh (2020)	CSR effort	Linear	–
28	Liu et al. (2020)	CSR effort	Linear	–

Table 2 (continued)

#	Authors	CSR coefficient/ Decision variable	CSR cost/ Profit term	CSR exhibition
29	Kumar et al. (2021)	Consumer surplus	Quadratic	–
30	Tat et al. (2021)	CSR effort	Non-linear	Donation
31	Dabaghian et al. (2022)	CSR effort	–	–
32	Liu et al. (2022a)	CSR investment	Quadratic	–
33	Vosooghidizaji et al. (2022)	CSR effort	Linear	–
34	Sabbaghnia et al. (2023)	CSR effort	Linear	Donation

resources to specific CSR activities. Qualitative studies often explore various aspects of CSR, such as donations, greening investments, and social welfare plans. In recent research, Modak et al. (2019a) introduced social work donation (SWD) as a specific CSR activity undertaken by socially responsible firms. Additionally, recycling activities have been interpreted as a form of CSR disclosure in the study by Panda et al. (2017). Despite the presence of some CSR conceptual studies, quantitative models specifically addressing CSR are not extensively explored in the literature. The scarcity of quantitative CSR models indicates a research gap in understanding and incorporating CSR activities into formal models and decision-making frameworks.

The existing literature on CSR in the context of SSC planning has limitations in terms of addressing business competitiveness and consumers' perception. Heydari and Mosanna (2018) argue that the representation of CSR in the literature is confined to CSR investment, CSR effort, and consumer surplus, which fail to capture the multidimensional aspects of CSR in real-world problems. While a few studies delve into the real-world perception of CSR, most of the literature provides a general definition of CSR without a well-justified problem setting. This lack of specificity hinders a comprehensive understanding of CSR's impact and implications in the context of SSCs. Furthermore, it is important to explore how different CSR strategies and activities influence consumers' purchasing behavior and their perceptions of a company's social responsibility. To facilitate a detailed comparison among CSR-related studies in SSC planning, Table 3 presents a comprehensive overview of the literature, highlighting the different perspectives, methodologies, and findings of these studies. It is evident that there are rooms for further research and exploration in understanding the diverse dimensions of CSR in the context of SSCs and its impact on business competitiveness and consumer perception.

3.2 Financial plus environmental

3.2.1 CEA considerations in SSCC

The concept of CEA has its roots in the seventeenth century, as environmental issues have been a longstanding concern (Bhate & Lawler, 1997). However, this phenomenon was officially introduced by Shrum et al. (1995). Since then, researchers and practitioners have delved into this phenomenon from various perspectives, examining its impact on different

Table 3 The comparison among CSR-related studies in SSC planning (for the meanings of abbreviations, see Appendix)

#	Authors	#	Integration Level	Coordination Mechanism	Equilibrium & Power Structure		Joint Studies	CSR activity conductor	Demand function (Type & Factors)					
					Stackelberg (Leader)	Other Structures			Additive/ Multiplicative	Linear/ Non-Linear	Price	CSR investment/effects	Consumer surplus	Other Factors
1	Ni et al. (2010)	2	Coor	WSP	S/F	Nash EQ		S	A	L	*	*		
2	Goering (2012)	2	Coor	2PT	M			M/R	A	L	*	*		
3	Hsueh (2014)	2	Coor	RS	-	Nash EQ		M	A	NL	*	*		
4	Panda (2014)	2	Coor	RS	M			M/R	A	L	*		*	
5	Panda et al. (2015)	3	Coor	WSP	M	Bargaining		M	A	L	*	*		
6	Modak et al. (2016a)	3	Coor	RS	M			M	A	L	*		*	
7	Panda and Modak (2016)	2	Coor	SPE	-	Bargaining		M/R	A	L	*		*	
8	Ma et al. (2017)	2	Coor	WSP, 2PT	R			M	A	L	*	*		Adv
9	Nematollahi et al. (2017)	2	Coor	Coll	-	Nash EQ		S	A	NL	*	*		
10	Panda et al. (2017)	2	Coor	RS	M	Bargaining	CLSC	M	A	L	*		*	
11	Heydari and Mosanna (2018)	2	Coor	CS	M			M	A	L	*	*		DS, CSA
12	Liu et al. (2018)	2	Coor	CS	R			S/R	A	L	*		*	
13	Nematollahi et al. (2018)	2	Coor	MOC	D			N.A	N.A	N.A	–	–	–	Inventory
14	Raj et al. (2018)	2	Coor	WSP, 2PT, GCS, RS, RGCS	S		CEA	B	A	L	*	*		Grn-Lv

Table 3 (continued)

#	Authors	#	Integration Level	Coordination Mechanism	Equilibrium & Power Structure		Joint Studies	CSR activity conductor	Demand function (Type & Factors)					
					Stackelberg (Leader)	Other Structures			Additive/ Multiplicative	Linear/ Non-Linear	Price	CSR investment/effects	Consumer surplus	Other Factors
15	Raza (2018)	2	Coor	RS	M	Bargaining		M	A	L	*	*		
16	Liu et al. (2019b)	3	Coor	-	R		GOV	R	A	L	*		*	
17	Hosseini-Motlagh et al. (2019b)	3	Coor	WSP	M	Bargaining		M	A	NL				Adv Inventory
18	Hou et al. (2019)	2	Coor	RS	FC	Nash EQ Diff-Games	GOV	S/FC	A	NL		*		Adv Quality
19	Liu et al. (2019a)	2	Coor Coop	TPM	R			S	A	L	*	*		
20	Liu et al. (2019c)	2	Coor	RC, RRC	–	Bargaining		M/R	A	L	*		*	
21	Modak et al. (2019a)	2	Coor	2PT	M	Bargaining	CLSC	M	A	L	*			SWD
22	Phan et al. (2019)	2	Coor	WSP, RP, RPM, RPC	M	Bargaining		M	A	L	*	*		Adv
23	Seyedhosseini et al. (2019)	2	Coor Coop Comp	2PT	M	Nash EQ		M	A	NL	*	*		
24	Mahdiraji et al. (2020)	3	Coor	CS, RS, PS, 2PT	M/R	Nash EQ		M	M	NL	*	*		Adv
25	Jokar and Hosseini-Motlagh (2020)	2	Coor	WSP, BB	M	Bargaining		M/R	A	NL	*	*		
26	Tian et al. (2020)	2	Coor	RS	-	Nash EQ	CEA	S	A	L	*	*		

Table 3 (continued)

#	Authors	#	Integration Level	Coordination Mechanism	Equilibrium & Power Structure		Joint Studies	CSR activity conductor	Demand function (Type & Factors)					
					Stackelberg (Leader)	Other Structures			Additive/ Multiplicative	Linear/ Non-Linear	Price	CSR investment/effects	Consumer surplus	Other Factors
27	Johari and Hosseini-Motlagh (2020)	2	Coor Comp	CS	M			M	A	L	*	*		
28	Liu et al. (2020)	2	Coor	Value-added	R	Bargaining		M	A	L	*	*		
29	Kumar et al. (2021)	2	Coor	RS, WSP	S			S	A	L	*	*		
30	Tat et al. (2021)	2	Coor	RS-CS	M			M	M	L	*			Donation, Order
31	Dabaghian et al. (2022)	3	Coor	QD	S			M	A	L	*			Return, Quality
32	Liu et al. (2022a)	3	Coor	CS	R		GOV	R	A	L	*	*		
33	Vosooghidizaji et al. (2022)	2	Coor	–	M/S			M/S	A	L	*	*		Info
34	Sabbaghnia et al. (2023)	2	Coor	RS	M	Nash	CEA	M	A	L	*	*		Donation

#	Authors	#	Uncertainty Considerations	Decision-makers (variables)		
				Supplier/Manufacturer	Firm/Retailer/Focal Company/Buyer	Distributer
1	Ni et al. (2010)	2	D	WSP, CSR	OQ	

Table 3 (continued)

#	Authors	#	Uncertainty Considerations	Decision-makers (variables)		
				Supplier/Manufacturer	Firm/Retailer/Focal Company/Buyer	Distributer
2	Goering (2012)	2	D	WSP	OQ	
3	Hsueh (2014)	2	S	WSP, CSR	OQ, P	
4	Panda (2014)	2	D	WSP	P	
5	Panda et al. (2015)	3	D	WSP	P	WSP
6	Modak et al. (2016a)	3	D	WSP	P	WSP
7	Panda and Modak (2016)	2	D	WSP	P, OQ	
8	Ma et al. (2017)	2	D	WSP,CSR	P, Adv	
9	Nematollahi et al. (2017)	2	S	CSR	OQ	
10	Panda et al. (2017)	2	S	WSP	OQ	
11	Heydari and Mosanna (2018)	2	D	DS	P	
12	Liu et al. (2018)	2	S	WSP	P, OQ	
13	Nematollahi et al. (2018)	2	D	–	P	WSP
14	Raj et al. (2018)	2	D	Grn-Lv	P, CSR	
15	Raza (2018)	2	S	WSP, CSR	P, OQ	
16	Liu et al. (2019b)	3	S	WSP	CSR, P, OQ	
17	Hosseini-Motlagh et al. (2019b)	3	S	WSP, CSR	OQ	WSP
18	Hou et al. (2019)	2	D	GrLvl, Prcs-dev	GrLvl, Prcs-dev, Adv	
19	Liu et al. (2019a)	2	D	WSP, CSR	P, OQ	
20	Liu et al. (2019c)	2	S	WSP	P	
21	Modak et al. (2019a)	2	S	WSP	P	

Table 3 (continued)

#	Authors	#	Uncertainty Considerations	Decision-makers (variables)		
				Supplier/Manufacturer	Firm/Retailer/Focal Company/Buyer	Distributer
22	Phan et al. (2019)	2	D/S	CSR	P	
23	Seyedhosseini et al. (2019)	2	D	CSR	P	
24	Mahdiraji et al. (2020)	3	D	CSR	P, Adv	
25	Jokar and Hosseini-Motlagh (2020)	2	S	WSP, CSR	OQ	
26	Tian et al. (2020)	2	D	WSP	P	
27	Johari and Hosseini-Motlagh (2020)	2	D	CSR	P	
28	Liu et al. (2020)	2	D	CSR	P	
29	Kumar et al. (2021)	2	D	CSR, WSP	P	
30	Tat et al. (2021)	2	S	Donation, Take-back	OQ	
31	Dabaghian et al. (2022)	3		WSP	P	WSP
32	Liu et al. (2022a)	3	D	WSP	CSR	
33	Vosooghidizaji et al. (2022)	2	D	CSR	P	
34	Sabbaghnia et al. (2023)	2	D	Donation, WSP	P	

stakeholders. This includes exploring the influence of consumers on business owners (Bansal & Gangopadhyay, 2003; Chartrand, 2005), as well as the effects of CEA on the operational decisions of SC members (Gossling et al., 2005) and entities (Ubilava et al., 2010). While CEA applications have gained attention in recent years, they are still relatively new in the context of SSCC research. The emergence of CEA primarily addresses the connection between environmental protection and economic development. Consumers play a crucial role in driving demand for eco-friendly products/services, as they are willing to pay higher prices for items with a higher eco-quality label. Interestingly, CEA not only stimulates this demand but also counteracts higher production costs associated with an eco-sensitive market (Du et al., 2015b). Consequently, this dual effect allows SC members to align two seemingly opposing objectives: environmental considerations and profit maximization goals.

The existing literature on environmental improvement primarily centers around two aspects: analyses of greening investments (Bi et al., 2017; Giri et al., 2018) and investigations into greening costs (Ghosh et al., 2020a, 2020b). However, there is a need for further analysis to address several key questions in this field. Firstly, is there another perspective or approach to quantifying environmental improvement that has not been explored? Secondly, which entity within the supply chain should take the responsibility of initiating and driving environmental improvement efforts? Lastly, is there a systematic method or framework for indexing and assessing the various factors that contribute to environmental improvement? These questions highlight the gaps in the current literature and emphasize the need for additional research to provide comprehensive insights into environmental improvement strategies in SSCC context.

One of the early studies that delved into the behavior of environmentally aware consumers focused on examining the influence of subsidy/penalty policies on improving environmental quality (Bansal & Gangopadhyay, 2003). The study concluded that subsidies have a more dominant impact compared to discriminatory penalty policies. This research served as a catalyst for many scholars to explore supply chain decisions in the presence of environmentally aware consumers (Yenipazarli, 2019; Zhang et al., 2015). Building upon this foundation, Swami and Shah (2013) investigated a dyadic supply chain in the context of environmental consciousness among consumers. Their work paved the way for three key developments in this field: (i) the integration of environmental considerations into pricing problems (Basiri & Heydari, 2017; Raza & Govindaluri, 2019), (ii) examining the impact of environmental awareness in complex supply chain networks, and (iii) considering uncertainty and supply chain dynamics in relation to environmental concerns (Bi et al., 2017).

CEA-related studies primarily focus on the impact of CEA on key decisions and the profitability of SCs. These studies examine both competitive (Liu et al., 2012) and cooperative (Hong & Guo, 2019) relationship structures among SC members. When considering decision structures, CEA studies mainly concentrate on operational-level decisions. It is noteworthy that almost all existing studies have primarily addressed simple two-echelon structures and have not investigated complex real-world cases. Consequently, the analysis of CEA in complex SC structures remains limited. Additionally, the stochastic nature of real-world problems has not been adequately considered in relation to CEA. Upon reviewing the literature, it is evident that only a few studies (Bi et al., 2017; Hong & Guo, 2019) have explored this issue. The current state of research suggests weak interactions between academic studies and the practical efforts in CEA-related studies. This indicates a literature gap that can be addressed by answering important questions such as: (i) Which problem settings should be addressed when dealing with uncertainty? (ii) Are there any priority schemes for addressing different uncertainties? (iii) How can optimal supply chain decisions be achieved in complex supply chain structures?

The analysis of key decisions in the existing literature provides intriguing insights, particularly in regard to SC members' division into upstream and downstream roles. Upstream decisions primarily focus on two key aspects: (1) pricing decisions, and (2) sustainability decisions, including abatement levels or investments in greening and eco-friendly initiatives (Song et al., 2022). Similarly, downstream decisions mirror this pattern, including pricing decisions, inventory decisions, and marketing decisions. This simplified sequence of decisions stems from the fundamental and straightforward structure of the SC and the simplified relationships among its entities. However, there is an interesting research opportunity to expand the scope of fundamental decisions made by SC members by developing more realistic models that consider the complex structure and interdependencies among independent and dependent entities within the SC. By undertaking such efforts to model the structure and relationships of these entities, researchers can gain a deeper understanding of the dynamics and complexities of decision-making within the SC, leading to more accurate and comprehensive insights.

In the analysis of the selected literature, the impact of coordination efforts and different coordinating mechanisms, such as collaboration/contracts, on key decisions within the SC is examined. Among the coordinating mechanisms, revenue-sharing contracts emerge as the most common contract in the CEA literature (Du et al., 2015b; Giri et al., 2018; Song & Gao, 2018; Xu & Xie, 2016; Yang & Chen, 2018; Yang et al., 2017a). The second most popular contract is cost-sharing (Hong & Guo, 2019; Yang & Chen, 2018), followed by the wholesale price contract (Du et al., 2015b; Giri & Bardhan, 2016; Yang et al., 2017a) as the third preferred option in CEA-related studies. Other contract types, such as price-only and two-part-tariff contracts (Hong & Guo, 2019), quantity discounts (Du et al., 2015b), price-discount sharing (Du et al., 2017), and return contracts (Zhang et al., 2015), have also been studied to varying degrees. However, there are still unexplored areas in channel conflict resolution when considering CEA, as other contract types have not been adequately investigated. The limited number and variety of under-studied contracts highlight the need for further research in combining coordinating contracts with the influence of CEA on the SC. Furthermore, the potential impact of information symmetry/asymmetry on sustainability levels within the supply chain is identified as an area with significant research potential (Ranjbar et al., 2021; Zhang et al., 2018). By exploring the interplay between information sharing and environmental awareness, researchers can uncover valuable insights into achieving sustainability objectives within the supply chain context.

The SC configuration is another intriguing area of research within the SSCC studies. Power structure (Xu & Wang, 2018; Xue & Zhang, 2018), maximum willingness to pay of consumers (Liu et al., 2012), and physical constraints such as capacity limitations (Zhang et al., 2015) have received considerable attention from researchers in recent years. However, it is evident that the number of quantitative studies in this specific field pales in comparison to the extensive body of qualitative research focused on understanding consumers' perception of environmentally friendly products. As a result, there is a significant dearth of mathematical and quantitative studies in this domain. The selected studies exploring SSCC in relation to CEA are analyzed in Table 4.

3.2.2 Coordination under carbon legislation

Carbon consideration and low-carbon policies have attracted the substantial interest of the parties involved. While environmental regulations is identified as a major driver in SSCM in different industries, joint carbon legislation and SCC are relatively less studied. In recent years, there has been vigorous attention toward implementing low-carbon ideas into the

Table 4 The comparison among CEA-related studies in SSCC literature (for the meanings of abbreviations, see Appendix)

#	Authors	#	Integration Level	Coordination Mechanism	Equilibrium & Power Structure		Joint Studies	Demand function (Type & Factors)					
					Stackelberg (Leader)	Other Structures		Additive/ Multiplicative	Linear/NL	Price	Greenness, Environmental quality	Abatement \ emission reduction	Other factors
1	Liu et al. (2012)	2	Comp	-	M			A	L	*	*		
2	Swami and Shah (2013)	2	Coor	2PT	M			A	L	*	*		
3	Du et al. (2015b)	2	Coor	WSP, RS,QDS	M			A	NL	*		*	
4	Zhang et al. (2015)	2	Coor	RT	M			A	L	*	*		CEA
5	Zhou et al. (2016)	2	Coor	CA,CA-ERCS	M		Carbon	A	L			*	GMC
6	Basiri and Heydari (2017)	2	Coor	Coll	–	Nash EQ		A	L	*	*		GMC
7	Chen et al. (2017)	2	Coor	2PT	–	Nash EQ		A	L	*	*	*	
8	Du et al. (2017)	2	Coor	PDS	M			A	L	*		*	
9	Ji et al. (2017)	2	Comp	-	M		Carbon	A	L	*		*	
10	Yang et al. (2017a)	2	Coor	RS, WSP	M/R		Carbon	A	L	*		*	
11	Giri et al. (2018)	2	Coor	RS	M		CLSC	A	L	*	*		Wrty
12	Ghosh et al., (2020a, 2020b)		Comp	–	–	Nash EQ	GOV	A	L	*	*		

Table 4 (continued)

#	Authors	#	Integration Level	Coordination Mechanism	Equilibrium & Power Structure		Joint Studies	Demand function (Type & Factors)					
					Stackelberg (Leader)	Other Structures		Additive/ Multiplicative	Linear/NL	Price	Greenness, Environmental quality	Abatement \ emission reduction	Other factors
13	Heydari et al. (2018a)	3	Coor	NLP	D			A	L	*	*		
14	Song and Gao (2018)	2	Coor	RS	M	Bargaining		A	L	*	*		
15	Xu and Wang (2018)	2	Comp	–	M	Bargaining	CLSC	A	L	*		*	
16	Yang and Chen (2018)	2	Coor	RS, CS	–	Nash EQ	Carbon	A	L	*		*	
17	Zu et al. (2018)	2	Coor	CS	M	Diff-Games	GOV	A	L	*		*	
18	Hong and Guo (2019)	2	Coor	PO, CS, 2PT	M			A	L	*	*		GMC
19	Li et al. (2019)	2	Coor	RS, CS	M	Bargaining		A	L	*	*		
20	Liu (2019)	2	Coor	RS	–	Nash EQ		A	L			*	GMC
21	Raza and Govindaluri (2019)	2	Coor	–	M/R			A	L	*	*		
22	Cao et al. (2020)	2	Coor	CS, BB				M	NL	*	*		
23	Heydari and Rafiei (2020)	2	Coor	WSP	–	Nash EQ	CSR	A	L		*		CSA

Table 4 (continued)

#	Authors	#	Integration Level	Coordination Mechanism	Equilibrium & Power Structure		Joint Studies	Demand function (Type & Factors)					
					Stackelberg (Leader)	Other Structures		Additive/ Multiplicative	Linear/NL	Price	Greenness, Environmental quality	Abatement \ emission reduction	Other factors
24	Heydari et al. (2020)	2	Coor	HGRS	R	Nash EQ		A	L	*	*		
25	Liang and Futou (2020)	2	Coor	BCS	M	Diff-Games	Carbon	A	L		*		GMC
26	Yu et al. (2020)	2	Coor	WP-BP,WP-RS	–	Diff-Games	Carbon	A	L	*	*		GMC
27	Huang and Yao (2021)	3	Coor	2PT	R	Nash EQ		A	L	*	*		
28	Gao et al. (2021)	2	Coor	2PT	R		GOV	A	L	*	*		
29	Mohsin et al. (2021)	2	Coor	WSP	M	Diff-Games		A	NL	*	*		
30	Qiao et al. (2021)	3	Coor	QD, CS	M		Carbon	A	L	*	*	*	
31	Xu et al. (2023)	2	Coor	WSP	M			A	L	*		*	Network
32	Mohsin et al. (2021)	2	Coor	WSP	M	Diff-Games		A	NL	*	*		
33	Qiao et al. (2021)	3	Coor	QD, CS	M		Carbon	A	L	*	*	*	
34	Wang et al. (2021b)	2	Coor	CS	R		Carbon	A	L	*		*	

Table 4 (continued)

#	Authors	#	Uncertainty Considerations	Decision-makers (variables)		
				Supplier/Manufacturer	Firm/Retailer/Focal Company	Distributer
1	Liu et al. (2012)	2	D	WSP, GrLvl	P	
2	Swami and Shah (2013)	2	D	WSP, GrLvl	P, GrLvl	
3	Du et al. (2015b)	2	D	WSP, AbateLvl	P	
4	Zhang et al. (2015)	2	S	WSP, RetC	OQ	
5	Zhou et al. (2016)	2	D	AbateLvl	Adv	
6	Basiri and Heydari (2017)	2	D	GrLvl	P, Adv	
7	Chen et al. (2017)	2	D	WSP, AbateLvl	P	
8	Du et al. (2017)	2	D	WSP, AbateLvl	P, AbateLvl	
9	Ji et al. (2017)	2	D	WSP, AbateLvl	P, Adv	
10	Yang et al. (2017a)	2	D	WSP, AbateLvl	OQ	
11	Giri et al. (2018)	2	D	WSP, Wrty	P	
12	Ghosh et al., (2020a, 2020b)		D	WSP, GrLvl	–	GOV* Subsidy
13	Heydari et al. (2018a)	3	D	GrLvl	P	Price
14	Song and Gao (2018)	2	D	WSP, GrLvl	P	
15	Xu and Wang (2018)	2	D	WSP, AbateLvl	P, Rcy	

Table 4 (continued)

#	Authors	#	Uncertainty Considerations	Decision-makers (variables)		
				Supplier/Manufacturer	Firm/Retailer/Focal Company	Distributer
16	Yang and Chen (2018)	2	D	WSP, AbateLvl	OQ	
17	Zu et al. (2018)	2	D	Subsidy,AbateLvl	GrLvl	
18	Hong and Guo (2019)	2	S	WSP, GrLvl	P, Adv	
19	Li et al. (2019)	2	D	WSP, GrLvl	P	
20	Liu (2019)	2	D	Adv, AbateLvl	P	
21	Raza and Govindaluri (2019)	2	D/S	WSP, GrLvl	P, GrLvl	
22	Cao et al. (2020)	2	D	WSP, GrLvl	P, GrLvl	
23	Heydari and Rafiei (2020)	2	D	GrLvl	CSR	
24	Heydari et al. (2020)	2	D	GrLvl	P	
25	Liang and Futou (2020)	2	D	GrLvl	Adv	
26	Yu et al. (2020)	2	D	WSP, GrLvl	P, Adv	
27	Huang and Yao (2021)	3	D	WSP	P	P
28	Gao et al. (2021)	2	D	WSP	P	
29	Mohsin et al. (2021)	2	D	WSP	P	
30	Qiao et al. (2021)	3	D	AbateLvl	AbateLvl	OQ
31	Xu et al. (2023)	2	D	WSP, Network	P	
32	Mohsin et al. (2021)	2	D	WSP	P	
33	Qiao et al. (2021)	3	D	AbateLvl	AbateLvl	OQ
34	Wang et al. (2021b)	2	D	WSP, AbateLvl	P	

SC decision-making process. These studies mainly develop simple production and inventory management models like EOQ, newsvendor problem (Du et al., 2015a; Hua et al., 2011; Song & Leng, 2012), and basic production planning decisions (Xu et al., 2016b). Carbon emission-related studies mainly focus on the environmental aspect of reducing economic costs imposed by the government or the pressure of the market (e.g., environmentally aware consumers and NGOs). On governmental intervention, the government is considered a decision-maker player in the SC and has the authority to levy carbon taxes, legislation, and policies. Cao et al. (2017) and Wang et al. (2017) are the only two studies that identified where the government is a decision-maker entity. Besides, in Yuyin and Jinxi (2018a) and Yuyin and Jinxi (2018b), the government's role is considered through carbon tax and subsidies. Considering the number of related studies addressing governmental intervention in SSCC and carbon emission abatement, a vast and untouched research avenue is to be investigated. In addition, the impacts of various types of carbon legislation are examined in the SSCC literature.

In addition to the coordination scope, another area of research that has emerged is focused on the remanufacturing problem within the context of carbon legislation. Yang et al. (2018b) investigated a dual-channel SC operating under a cap-and-trade mechanism, with a particular emphasis on optimizing pricing decisions. Similarly, Yang et al. (2018a) examined the manufacturer's choices regarding channel selection and emission abatement strategies, considering the influence of environmentally aware consumers. Huang et al. (2016) developed a three-stage GSC model using game theory to optimize various decisions and their impact on the environmental performance. Their study provides valuable insights for managers, helping them understand the trade-offs between sustainability and profitability more effectively.

Additionally, Yang et al. (2018c) introduced the concept of holding costs for emission quotas and carbon prices as new considerations at the operational level within the framework of cap-and-trade policies. Bai and Meng (2019) investigated risk aversion in a dyadic SC under cap-and-trade regulations using a game model led by a retailer, and their findings suggested that risk aversion could lead to higher benefits under certain circumstances. Inventory control policies have also been explored within the realm of SSC literature. Bazan et al. (2015) explored various inventory control policies aimed at mitigating conflicts of interest within an SC.

Similarly, there is a separate research stream within the literature that focuses on carbon emission reduction efforts without relying on specific carbon policies. For example, Hong et al. (2018) proposed a dynamic programming-based optimization model to evaluate greenhouse gas emissions across the SC. Their decentralized decision-making structure included activities such as material extraction, production processes, and transportation, providing valuable insights into the reduction of greenhouse gas emissions throughout the SC.

Carbon legislation types Different carbon policies have different impacts on the abatement level and key decisions of the SCs. Four central carbon policies are identified in the SSCC literature: (1) Cap-and-trade policies, (2) Emission constraints, (3) Carbon tax, and (4) Low carbon subsidy. The cap-and-trade policy is the most common mechanism applied in SSCC literature (Heydari & Mirzajani, 2021; Khanna & Yadav, 2021; Taleizadeh et al., 2021; Tat et al., 2023). Second carbon legislation, emission constraint, implies considering a quota of permitted emission for an SC, and violations from this constraint are treated in two ways: (i) penalty for extra emission units, (ii) no extra emission allowed. Reports from varying studies in the SSCC area, considering emission constraints, suggest that each SC needs tailored legislation to address the required balance between economic, social, and environmental objectives. The third carbon legislation, the carbon tax mechanism, has been

under investigation in the SSCC literature for a while (Khanna & Yadav, 2020). Joint studies on coordination literature and carbon tax commenced from Ma and Gao (2013), where the abatement investment of manufacturers is optimized for environmentally sensitive consumers. Lastly, the fourth carbon legislation, low carbon subsidy, is applied to certain products under specific conditions, and a few studies merely addressed this legislation in the SSCC literature. Subsidy policies are the opposite of the carbon tax mechanism, and there is a thin body of literature on this issue in conjunction with SSCC. Yuyin and Jinxi (2018a, 2018b) and Cao et al. (2017) studied SCC by considering carbon abatement under the carbon subsidy policy. The combined policies, where the manufacturer gets the subsidy when it operates at a low-carbon level and pays tax when emitted over a specified limit, are ignored entirely. Following these conventional policies, some researchers have advised some extensions as Zero-Carbon-Conversion Alliance (Zhou et al., 2016).

There is an ongoing discussion among practitioners and environmentalists about the advantages/disadvantages of different carbon policies. Still, environmentally-concerned authors believe that the cap-and-trade policy is permission to pollute. Carbon emission tax provides a confidence level on emission prices, while cap-and-trade provides certainty regarding emissions quantities. In a deterministic environment, both policies result in identical emission quantity/unit cost.[1] However, in real-world applications, wherein problem parameters are tainted with uncertainty, it is difficult to determine accurate environmental damages. In terms of applicability, the cap-and-trade system seems more advantageous in curbing total emission quantities. By addressing the uncertainty of emission abatement costs, tax policy is favourable from the corporates' perspective (Goulder & Schein, 2013). Defining a price interval for emissions results in a hybrid cap-and-tax policy (Hepburn, 2006). Further, both policies could be implemented concurrently (Bruce et al., 1996).

Based on Table 5, it is evident that all carbon-related studies within the scope of SSCC have been conducted in a two-tier setting, involving a pair of entities out of the three main players: government, manufacturer, and retailer. While certain studies, such as Cao et al. (2017) and Wang et al. (2017), have explored different carbon policies within a two-tier supply chain under government emission tax or subsidy, there remains a need for further research on the role of the government in SSCC. The power structure and the implications of having a leading entity in carbon-focused SCs have garnered attention from the academic community, particularly in recent years. Studies by Yang et al. (2017a) and Xia et al. (2018) have examined various power structures where different entities within the supply chain can assume the role of the channel leader. This assumption has led to insightful managerial and practical findings in the field.

3.2.3 RSC/CLSC coordination

Closed-loop supply chain management (CLSCM) represents a departure from traditional SCM practices by incorporating reverse logistics, product returns, and remanufacturing processes (Guide et al., 2003). By adopting CLSCM, organizations can align their profit-driven objectives with sustainable practices (Saha et al., 2016). CLSCM and RSC studies are part of the broader framework of SSCM and have emerged as effective mechanisms for mitigating the environmental impact of end-of-life products. The coordination of CLSC and RSC activities has been extensively explored in the literature, providing valuable insights into achieving environmental sustainability within supply chain operations (Modak et al., 2016d).

[1] https://www.theguardian.com/environment/2013/jan/31/carbon-tax-cap-and-trade

Table 5 The comparison among Carbon regulation/legislation-related studies in SSC planning (for the meanings of abbreviations, see Appendix)

#	Authors	#	Integration Level	Coordination Mechanism	Equilibrium & Power Structure		Joint Studies	Carbon legislation		
					Stackelberg (Leader)	Other Structures		Carbon Tax	Cap-and-trade	Carbon emission constraint
1	Ma and Gao (2013)	2	Coor	WSP	M		CEA	*		
2	Luo et al. (2016)	1	Comp,Coop						*	
3	Xu et al. (2016a)	2	Coor	RS,2PT	S				*	
4	Bai et al. (2017)	2	Coor	RPS,2PT	M				*	
5	Cao et al. (2017)	2	–	–	GOV		GOV	*	*	
6	Ji et al. (2017)	2	Comp	–	M		CEA		*	
7	Wang et al. (2017)	3	Comp Coop	–	GOV/M		GOV	*		
8	Xu et al. (2017)	2	Coor	WSP,CS 2PT	M		CEA		*	
9	Yang et al. (2017a)	2	Coor	RS WSP	M/R		CEA	*		
10	Yang et al. (2017b)	2	Coor	RS	M	Nash EQ			*	
11	Peng et al. (2018)	2	Coor	RS,QD RSS	S		CEA		*	
12	Xia et al. (2018)	2	Coor	SP	R/M		CSR		*	
13	Xu et al. (2018a)	2	Coor	PD	S					*
14	Xu et al. (2018b)	2	Coor	RS	M		CEA		*	
15	Yuyin and Jinxi (2018a)	2	Coor	ECS,CCS BiCS	M		GOV	*		
16	Yuyin and Jinxi (2018b)	2	Coor	CCS	M		GOV	*		
17	Bai et al. (2019)	2	Coor	RS	M				*	
18	Hosseini-Motlagh et al. (2019a)	2	Coor Comp	3PC	M	Bargaining		*		
19	Ma et al. (2019)	3	Coor	RS,CS	R				*	

Table 5 (continued)

#	Authors	#	Integration Level	Coordination Mechanism	Equilibrium & Power Structure		Joint Studies	Carbon legislation		
					Stackelberg (Leader)	Other Structures		Carbon Tax	Cap-and-trade	Carbon emission constraint
20	Bai et al. (2020)	2	Coor	RS, 2PT	M			*		
21	Qian et al. (2020)	2	Coor,Coop	WSP,2PT	M	Bargaining	CSR		*	
22	Zhou et al. (2020)	3	Comp	–	GOV		CEA	*		
23	Lee and Choi (2021)	2	Coop	–		Nash EQ	CEA			*
24	Liu et al. (2021)	2	Coor	CS		Nash EQ	CEA			*
25	Ebrahimi et al. (2022)	2	Coor	WSP	R		GOV		*	

#	Authors	#	Demand function (Type & Factors)						Uncertainty Considerations	Decision variables		
			Additive/ Multiplicative	Linear/NL	Price	Abatement effort/ Investment	Emission rate/ quantities	Other factors		Supplier/Manufacturer	Firm/Retailer/Focal Company	Distributer
1	Ma and Gao (2013)	2	A	L	*	*			D	WSP,EmRd	P	
2	Luo et al. (2016)	1	A	L	*		*		D	WSP,GrLvl	-	
3	Xu et al. (2016a)	2	A	L	*	*			D	WSP	P,GrLvl	
4	Bai et al. (2017)	2	A	L	*		*	Promotion, Time	D	WSP,GrLvl	P,Adv	
5	Cao et al. (2017)	2	A	L	*	*			D	WSP,EmRd	-	GOV* Subsidy
6	Ji et al. (2017)	2	A	L	*	*			D	WSP, AbateLvl	P, Adv	
7	Wang et al. (2017)	3	M	NL	*				S	WSP	OQ	GOV* Tax
8	Xu et al. (2017)	2	A	L	*	*			D	EmRd	P	

Table 5 (continued)

#	Authors	#	Demand function (Type & Factors)						Uncertainty Considerations	Decision variables		
			Additive/ Multiplicative	Linear/NL	Price	Abatement effort/ Investment	Emission rate/ quantities	Other factors		Supplier/Manufacturer	Firm/Retailer/Focal Company	Distributer
9	Yang et al. (2017a)	2	A	L	*	*			D	WSP, AbateLvl	OQ	
10	Yang et al. (2017b)	2	A	L	*		*		D	WSP, EmRd	P	
11	Peng et al. (2018)	2	M	NL	*		*		S	WSP	OQ,EmRd	
12	Xia et al. (2018)	2	A	L	*		*	Promotion	D	EmRd	Adv	
13	Xu et al. (2018a)	2	A	L	*				D	WSP	P	
14	Xu et al. (2018b)	2	A	L	*	*			D	WSP,EmRd	P	
15	Yuyin and Jinxi (2018a)	2	A	L	*		*	Energy saving	D	WSP, EmRd,Engy	P	
16	Yuyin and Jinxi (2018b)	2	A	L	*		*	Energy saving	D	WSP, EmRd,Engy	P	
17	Bai et al. (2019)	2	A	L	*	*			D	WSP,GrLvl	P	
18	Hosseini-Motlagh et al. (2019a)	2	A	L		*		Sustainability level	D	GrLvl	GrLvl	
19	Ma et al. (2019)	3	M	NL	*			Freshness	D	WSP	P, OQ	Freshness
20	Bai et al. (2020)	2	A	L	*	*		Tech. Inv	S	WSP,GrLvl	P, effort	
21	Qian et al. (2020)	2	A	L	*	*			D	WSP,GrLvl	P	
22	Zhou et al. (2020)	3	A	L	*	*	*		D	WSP	P	GOV* Tax
23	Lee and Choi (2021)	2	A	L		*			D	EmRd	EmRd	Carbon footprint
24	Liu et al. (2021)	2	A	L	*	*	*		D	WSP, AbateLvl	OQ	
25	Ebrahimi et al. (2022)	2	A	L	*	*	*	Quality	S	WSP,GrLvl	P, GrLvl	

Research on RSC, considering social advantages, is traced back to Sasikumar and Kannan (2009). Next, Bazan et al. (2016) further investigated the environmental implications in analyzing and modelling the reverse logistics inventory systems. Based on the RSC pricing and coordination literature body, profit (cost) maximization (minimization) is considered as the performance measure of the efficiency of RSC operations. However, the social advantages from RSCs have rarely been considered so far (Li et al., 2017). Corbett and Savaskan (2003) is one of the first studies analyzing CLSCs and different aspects of coordination issues in CLSCs. Following, Savaskan et al. (2004), and Savaskan and Van Wassenhove (2006) explored the CLSC coordination problem in the retailer-collection mode. To extend the border of literature on CLSCs/RSCs, Ghosh et al. (2018) studied pivotal decisions under competition and collaboration between primary manufacturers and remanufacturers. CLSCs integrations with CSR, CEA, and carbon-related studies are rigorously investigated. For example, Modak et al. (2019a) defined social work donation (SWD) as a CSR activity of a socially responsible firm in a CLSC structure. Similarly, Wang et al. (2019) studied recycling/product donation as environmental/social responsibilities in a dyadic RSC. Their results indicate a tenacious relationship between the economic profit perspective and environmental/social performance. Later, Hosseini-Motlagh et al. (2020c) and Liu et al. (2021) investigated the interactions of CLSCs in a socially aware market-place. Their results indicate that channel coordination would benefit both the monetary and sustainable goals.

The contract-based coordination approach is used to achieve channel coordination and solve channel conflict in CLSCs. There is plenty of room for further developments on both coordinating mechanisms as well as problem statements. The factors that influence demand function are poorly addressed in the existing literature. Not only these factor sets are insufficient, but also their interactions have not been adequately investigated yet. Additionally, the power structure and impacts on optimal strategies and key decisions have been given less attention. The structure, setting, and key decisions of coordination problems in CLSCs have not been thoroughly explored to promise an obscure and open field for further investigations. An engrossing topic worth deep examination is the competition among newly manufactured and remanufactured items. Recall that CEA is stimulating the demand balance in favor of remanufactured items; the threshold analysis along with the pricing and SCM principal decisions have not been under the attention of academia nor business owners. In the CLSC network design problem, the salvage value/shortage penalty is broadly considered while there exists a significant lack of thorough analysis in the CLSC coordination problem. Table 6 provides an overview of existing CLSC/RSC related studies in the SSCC literature.

3.2.4 SSCC under governmental interventions

The existing literature on SSCC can be approximately divided into two main groups, studies exploring operational decisions with governmental interventions and studies investigating the channel members' behaviour without governmental interventions. Government intervention is manipulating the market economy through legislation and regulations introduced by legal authorities. Some scholars believe that the law of demand and supply cannot necessarily guarantee economic equilibrium; thus, government intervention is inevitable in some countries/regions to regulate the economy. For instance, Keynesianism is one of the central doctrines supporting this idea (Farmer, 2017). More or less, governmental intervention is believed to boost sustainability improvement progress in today's free-market and business world (Ling et al., 2022; Rodríguez et al., 2015). The intervention role is crucial in addressing monopolistic markets. In a monopolistic market, the firm may apply abusive behaviour to maintain its authority, leading to a significant welfare loss. Nevertheless, this intervention

Table 6 The comparison among CLSC/RSC-related studies in SSCC literature (for the meanings of abbreviations, see Appendix)

#	Authors	#	Integration Level	Coordination Mechanism	Equilibrium & Power Structure		Joint Studies	Patent Owner
					Stackelberg (Leader)	Other Structures		
1	Choi et al. (2013)	3	Coor	–	M/R			M
2	Hong et al. (2015)	2	Coor	BB,CA	M		CEA	M
3	Gao et al. (2016)	2	Coor	2PT	M/R	Nash EQ		M
4	Zhang and Ren (2016)	3	Coor	RES,2PT	M		CEA	M
5	Bazan et al. (2017)	2	Coor	VMI-CS			Carbon	M
6	Heydari et al. (2017)	2	Coor	QDS,IF				M
7	Li et al. (2017)	3	Coor Comp Coop	–	RM		CSR	RM
8	Panda et al. (2017)	2	Coor	RS	M	Bargaining	CSR	M
9	Xie et al. (2017)	2	Coor Coop	RS	M			M
10	Ghosh et al. (2018)	2	Comp Coop	2PT,RS				M
11	Heydari and Ghasemi (2018)	2	Coor	RS				RM
12	Heydari et al. (2018b)	2	Coor	RS				R
13	Xu and Wang (2018)	2	Coor		M	Nash EQ	CEA	M
14	Chen and Akmalul'Ulya (2019)	3	Coor	RPS	M		GOV CEA	M
15	Modak et al. (2019b)	3	Coop		M		CSR	M
16	Wang et al. (2019)	2	Coor	2PT,RS	M	Bargaining	CSR,CEA	M
17	Zheng et al. (2019a)	3	Coor Coop	VWS	M/R/C	Bargaining		M

Table 6 (continued)

#	Authors	#	Integration Level	Coordination Mechanism	Equilibrium & Power Structure		Joint Studies	Patent Owner
					Stackelberg (Leader)	Other Structures		
18	Zheng et al. (2019b)	3	Coor Coop	CGT	M	Nash EQ Bargaining		M
19	Hosseini-Motlagh et al. (2020a)	2	Coor Comp	WSP	M		CSR	M
20	Hosseini-Motlagh et al. (2020b)	3	Coor Comp	CT				M
21	Zhang et al. (2020)	2	Coor Comp	RS				M
22	Toktaş-Palut (2021)	3	Coor	2PT				M
23	Wang et al. (2021a)	2	Coor	2PT,PS GSCS	M		CSR GOV	M
24	Mondal and Giri (2021)	3	Coor	RS, CS	M/R		CSR	
25	Zheng and Hong (2022)	2	Coor	2PT, RS	M/R		GOV	M

#	Authors	#	Demand function (Type & Factors)					Uncertainty Considerations	Decision variables		
			Additive/Multiplicative	Linear/NL	Price	Sales effort	Other factors		Supplier/Manufacturer/ Remanufacturer	Firm/Retailer/Focal Company/Remanufacturer	Collector
1	Choi et al. (2013)	3	A	L	*			D	WSP, BB	P, OQ	C.Inv
2	Hong et al. (2015)	2	A	NL	*		Adv	D	WSP	P, Adv	C.R
3	Gao et al. (2016)	2	A	L	*	*	Coll.E	S	WSP, C.Inv	P, Adv	

Table 6 (continued)

#	Authors	#	Demand function (Type & Factors)					Uncertainty Considerations	Decision variables		
			Additive/Multiplicative	Linear/NL	Price	Sales effort	Other factors		Supplier/Manufacturer/ Remanufacturer	Firm/Retailer/Focal Company/Remanufacturer	Collector
4	Zhang and Ren (2016)	3	A	L	*			D	WSP, Lic	P	WSP, C.P
5	Bazan et al. (2017)	2	-		*			D	Inventory decisions		
6	Heydari et al. (2017)	2	A	L	*		REC fee	S	WSP, REC	Disc	
7	Li et al. (2017)	3	A	L	*			S	WSP	P	C.P
8	Panda et al. (2017)	2	A	L	*		ConsRS	S	WSP	OQ	
9	Xie et al. (2017)	2	A	NL	*		Adv	D	WSP	P, Adv	
10	Ghosh et al. (2018)	2	A	L	*			D	WSP, Lic	P, C.Inv	
11	Heydari and Ghasemi (2018)	2	A	L	*		REC fee	D	WSP, REC		P
12	Heydari et al. (2018b)	2	A	L	*		REC fee	S	REC	P	
13	Xu and Wang (2018)	2	A	L	*		EmRd	D	WSP,EmRd	P,REC	
14	Chen and Akmalul'Ulya (2019)	3	A	L	*	*		D	WSP,GrLvl, RR	P,GrLvl RR	

Table 6 (continued)

#	Authors	#	Demand function (Type & Factors)					Uncertainty Considerations	Decision variables		
			Additive/Multiplicative	Linear/NL	Price	Sales effort	Other factors		Supplier/Manufacturer/ Remanufacturer	Firm/Retailer/Focal Company/Remanufacturer	Collector
15	Modak et al. (2019b)	3	A	L	*		ConsRS	D	WSP	P	REC
16	Wang et al. (2019)	2	A	L	*		Coll.E	D	WSP, C.R.,DS	P, OQ,DS	
17	Zheng et al. (2019a)	3	A	L	*			D	WSP	P	P
18	Zheng et al. (2019b)	3	N.A	N.A	*			D	WSP, PQ	P	P
19	Hosseini-Motlagh et al. (2020a)	2	A	L	*		CSR	D	P	CSR	
20	Hosseini-Motlagh et al. (2020b)	3	A	L	*		E.Red	D	WSP, Egy	P	C.R
21	Zhang et al. (2020)	2	A	L	*		Quality	D	WSP, Quality	P	
22	Toktaş-Palut (2021)	3	A	L	*		E.Red	D	P	GrLvl	P
23	Wang et al. (2021a)	2	A	L	*		ConsRS	D	WSP	P, REC	
24	Mondal and Giri (2021)	3	A	L	*		CSR, Quality	D	WSP, CSR	P, CSR	C.R
25	Zheng and Hong (2022)	2	A	NL	*		EEC	D	RR	P	

requires extreme caution, as any mistake may jeopardize the social welfare and sustainability practice.

Given published works in SSCC literature, governments' interventions are mostly modelled as governments' role in making carbon legislation. In CLSCs and RSCs, governments seek to convince SC members to participate in remanufacturing/recycling of end-of-life products. Governmental intervention models in CEA and CSR-related SSCC studies are less studied. Tables 3 and 4 convey such governmental interventions in SSCC literature. Governments' tools could be narrowed down to subsidy-penalty incentives and controlling policies and legislation over business activities. Robust subsidy plans could eventually lead to promotions in the sustainable development of business. As there are few studies on governmental interventions in the SSCC, targeted incentives could be further studied in this area (Eriksson et al., 1998; Tuszynski & Stansel, 2018). Studies like Chen and Su (2019) and Zhang and Yousaf (2019) investigate governmental policies in the SCC problem with sustainability considerations. Liu et al. (2022b), Kang et al. (2021), Hosseini-Motlagh et al. (2022), and Mondal et al. (2022) have recently analyzed the coordination problem in the context of sustainability and government subsidy. One can run the gamut from pharmaceutical waste management (Tat & Heydari, 2021; Tat et al., 2020) to fairness concerns in the poverty alleviation supply chain (Kang et al., 2021) and CSR initiatives.

3.3 SSCC under TBL

There is a noticeable scarcity of studies that address the complex application of sustainability considering all three pillars: economic profit, social responsibility, and environmental greening efforts. Many studies tend to focus on pairwise combinations of sustainability pillars, resulting in a gap in understanding the interactions among all three dimensions. However, in recent years, there have been informative efforts to model and analyze the fundamental features of sustainability in the context of SCC (Biswas et al., 2018; Heydari & Rafiei, 2020; Qian et al., 2020; Raj et al., 2018). For example, Heydari and Rafiei (2020) examined a dyadic SSC with socially and environmentally aware consumers and proposed a coordination problem that takes into account all three aspects of sustainability and applied a game-theoretic approach to achieve a win–win outcome for both SC members. The developed models by Heydari and Rafiei (2020) have recently been developed to include uncertainty considerations (Rafiei et al., 2023).

Due to the limited number of studies that utilize the TBL approach in the context of SCC, there is still much room for further investigations. This research avenue calls for more rigorous exploration by both academics and practitioners to fully understand and address the interactions among economic, environmental, and social dimensions of sustainability in SSCC problems.

4 Methodological approaches

From a methodological perspective, the literature on SSCC primarily employs two main approaches: (1) Game-theoretic approaches and (2) Contract-based coordination mechanisms. These two approaches commonly overlap and are used to analyze the structure of the supply chain and investigate channel conflicts. This classification provides further insights and sheds light on other aspects of SSCC problems.

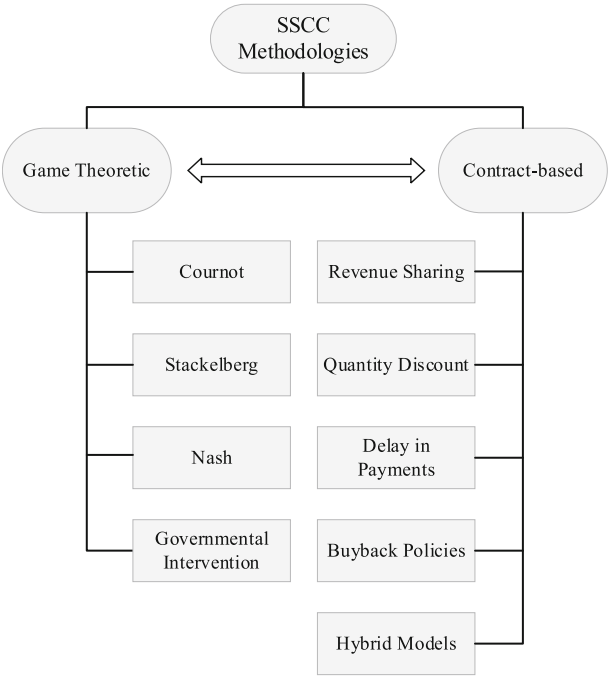

Fig. 2 Classification of SSCC methodologies

The game-theoretic approach enables researchers to model the interactions and decision-making of different entities within the SC as strategic players. It helps in understanding the incentives and behaviors of these players and exploring potential coordination strategies to achieve desirable outcomes. Game theory provides a valuable framework for analyzing conflicts, competition, and cooperation within the supply chain. Conversely, the contract-based approach focuses on designing incentive mechanisms through agreements. This approach involves developing contractual terms, such as pricing and revenue/cost-sharing arrangements, to align the interests of supply chain members and promote coordination. Contracts serve as governance mechanisms that provide incentives and establish rules for collaboration and coordination.

Figure 2 depicts the methodological structure of the SSCC problem. The Cournot duopoly, Stackelberg competition, and Nash equilibrium are common economic approaches applicable in this issue. The government's intervention could be classified under this branch. Other competition schemes are rarely addressed in SSCs; e.g., Bertrand competition has not been studied in terms of sustainability or coordination. Contract-based studies are the second branch to be identified. The number of popular contracts is not even a handful; however, some hybrid approaches are emerging in addressing coordination problems in SSCC. This trend needs to be amplified by introducing new ideas and approaches.

4.1 SSCC via contracts

Channel coordination motives are essential for mitigating the conflict of interests among SC members. In a perfect profit-maximizing setting, the issue of double marginalization can

often be resolved through conventional revenue or cost-sharing schemes. However, in cases involving CSR, CEA, carbon policies, and government intervention, it becomes necessary to design specialized contracts to address the inefficiencies arising from double marginalization.

In the contract-based SSCC problem, the diversity of coordination contracts is promising, although there is still room for further enrichment by utilizing new contracts in this context. Figure 3 depicts the frequency of the most popular contracts in the SSCC problem, i.e., RS, CS, WSP, and 2PT. From Fig. 3, one learns that favorite contracts differ from one area to another. Further, CS and WSP contracts are less investigated in CLSC/RSC studies addressing coordination problems. However, there are many contracts in SSCC literature, such as buy-back, sales-rebate, quantity-discount, etc. These contracts need to be investigated in SSCC problems to find out whether they could resolve the channel conflict or not. Besides, the superiority/inferiority of each had to be addressed in the SSCC problem. A proper contract is required to solve the inefficiency of operational decisions in SCs caused by individual choices. Analytical results exhibit that the more decentralized the SC decision-making structure, the more the channel profit suffers.

Based on the SSCC studies' detailed examination, the most common contracts are revenue/cost-sharing (and its extensions) or pricing schemes like WSP. Additionally, WSP is widespread because of its simple nature, even though it fails to resolve the channel conflicts properly. Despite this flaw, this contract generally serves as the lower bound in coordination problems. Furthermore, the current findings reveal that a revenue/cost-sharing contract is one the most favourable mechanisms in SSCC literature owing to the flexibility in distributing extra earned profit among SC members and resolving channel conflicts when members have equal bargaining powers. If channel members are not equal in terms of channel power, 2PT contracts will be more favourable to the SC leader due to its ability to extract the follower's profit values. While enormous costs of greening efforts are reported as a fatal barrier in altering from conventional business structures to SSCs, In practice, cost-sharing contracts are reported to be effective in coordinating, primarily, high investments of greening efforts.

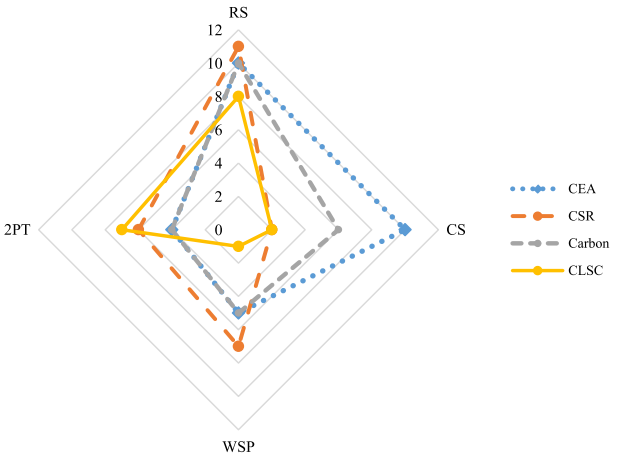

Fig. 3 Most frequent contracts in different SSCC branches

4.2 SSCC via game-theoretic approaches

Game-theoretic approaches range from simple price transfer mechanisms in a Cournot game to the advanced Shapley value in bargaining models. The Stackelberg game structure is the most utilized game model in the SSCC literature. This approach is used to clarify the power structure in SCs. Motivated by real-world problems, the number of manufacturer-led studies is abundant compared to retailer-led game structures. Retailer-led structures mainly focus on case studies addressing well-known grocery distribution stores (e.g., Wal-Mart). Furthermore, uncertainty considerations are often overlooked, resulting in a relatively small number of problems with stochastic elements in this area compared to deterministic ones. Some studies have developed analytical efforts to reveal differences between various power structures in game-theoretic models. For example, Zhang et al. (2019) investigated SSC's operational decisions under three power structures: manufacturer-led, retailer-led, and vertical Nash equilibrium. Distinct power structures have different impacts on operational decisions. Mixed approaches like Stackelberg-Cournot, Stackelberg-Collusion, Nash-Cournot, and Nash-Collusion are not well addressed in the SSCC literature.

5 Research gaps and possible future research directions

The analysis of research gaps centers on the interactions between sustainability pillars, with the aim of highlighting potential avenues for future research. This review emphasizes the need for heightened attention to the coordination problem, especially when addressing the inherent uncertainties in real-world scenarios and case studies. Recent years have seen some exploration of operational decisions under uncertainty, indicating untapped potential in this field. Furthermore, a deficiency in research attention becomes evident across all three subcategories introduced in this study. The existing literature on SSCC problems primarily focuses on simplified two-echelon SCs. Notably, there is a shortage of studies considering three-echelon structures, and even when they do, intricate relationships among SC members are often overlooked. One notable aspect observed in SSCC literature pertains to the prevalent utilization of demand functions, typically manifesting as additive and linear functions. This choice results from the necessity to obtain closed-form solutions, which in turn offers significant analytical potential for deriving managerial insights. Closed-form solutions gain enhanced tractability through the application of constraining assumptions. However, as the body of the literature promises, the more complex the demand function, the more the findings are realistic. When it comes to solving complex problems, the utilization of data-driven methods and machine learning approaches for modeling complex decision-making processes may provide a promising solution within the SSCC area of research. Additionally, substantial potential exists in exploring competition and its applications within the context of future SSCC problems, encompassing both vertical and horizontal competition. This area requires substantial attention from both academic researchers and practitioners. In addition, the consideration of risk attitudes among SC members has been largely neglected in previous studies on SSCC. Most studies assume that players are risk-neutral, failing to account for the potential impact of risk aversion on coordination decisions. However, recent research has recognized the importance of risk aversion and has employed common criteria such as Value-at-Risk (VaR), Conditional-Value-at-Risk (CVaR), and mean–variance analysis to gain insights into the coordination issues in sustainability literature. Another noteworthy aspect that has been explored in the context of sustainability is the dual-channel SC (Sana, 2022b). While the

Table 7 Research gap and unanswered question in SSCC literature categories

Category	Level of literature maturity	Main identified issues	Main unanswered questions
Financial + Social	Poor	CSR concept is not defined in practice	How could real-world CSR activities be effectively integrated into SSCC problems? How could the abstract concept of CSR be brought closer to reality?
Financial + Environmental	Relatively rich	Real-world problems are less investigated	How can developed optimization models be applied to real case studies?
Financial + Social + Environmental	Very poor	No significant modelling effort is identified	How can optimized SSCC models be developed to incorporate all the three sustainability pillars? What are the interactions of the three sustainability pillars in SSCC problems? How to make SSCC models by considering TBL more applicable for real-world situations?

dual-channel problem is not new in conventional and SSCM literature, there is still a need for further investigation and analysis of this issue in SSCC. Finally, information asymmetry in SSCC problems is a promising area for further exploration which brings models one step closer to reality. Table 7 classifies main unanswered questions and research gaps in the SSCC literature.

Here, the discussion centers on specific mutual properties shared by the categories introduced in Table 7, shedding light on key aspects of the analysis. Further examination of additional features is presented in the following subsections.

5.1 Financial plus social

Social concerns of business owners are motivated mainly by the pressure of legal regulations. Until recently, business owners considered social responsibility practices as as beneficial but costly exercises for their corporations. However, these views are altered due to undeniable economic outcomes of CSR practice. The benefits of CSR are explored through three critical internal processes of companies; (1) human resources, (2) sales and marketing, and (3) operations management and enterprise efficiency. This study has concentrated on quantitative

models of CSR in coordination problems, which turns out to be a handful. Two main insights are extracted regarding the interactions between financial and social aspects of an SSCC problem: (1) the ambiguity of CSR definition, and (2) the scarcity of proper quantitative models when it comes to CSR practices. As mentioned earlier, there are considerable numbers of studies investigating the impact of CSR activities on human resource processes (employee recruitment, retention, and motivation) or sales efforts qualitatively. In contrast, the number of studies drops noticeably in investigating quantitative features of CSR practices. The same pattern regarding CSR interpretation is also identified in studies addressing CSR applications in SSCC problems, where authors, in most of the existing studies, tend to illustrate it with general examples of CSR practices. Studies are required to focus on finding a clear perception of CSR and its applications on quantitative SSCC models. Although, studies like Heydari and Mosanna (2018), Modak et al. (2019a), Pahlevani et al. (2021), and Mosanna et al. (2022) define CSR through real-world applications of socially responsible firms.

5.2 Financial plus environmental

SSCC literature suggests that higher profits are achievable, even under the pressure of greening costs. It is already discussed that greening requires huge budgets. This cost is believed to be one of the barriers in implementing sustainability into a business as stakeholders seek to maximize their earnings, and most of them are profit-oriented decision-makers. However, existing consumers' awareness and sensitivity toward environmental issues have enough potential to compensate for greening costs through demand stimulation and consumers' willingness to pay.

In the literature, GSCs and SSCs are usually used interchangeably in the SSCC literature. Although exact definitions of green and sustainable terms are provided in SCM literature (Christopher, 2016), these technical terms are used interchangeably in SSCC literature. This ambiguity has spread to other subcategories in SSCC studies, like CEA and CSR. For instance, product greenness level is one of the widespread indicators in addressing sustainability. Nonetheless, this term could not be interpreted as product sustainability but used in various SSCC literature studies. In other observations from the existing literature, although CEA's impact on operational decisions is well addressed, similar to the CSR case, this phenomenon's exact definition is not justified in SSCC problems. Most studies introduced a price sensitivity coefficient to include consumers' perceptions about environmental awareness, but they failed to introduce CEA's real-world manifestation. The body of the existing literature needs profound recognition to fill out this gap.

In the SSCC literature related to carbon legislation, many models treat carbon trading prices as constant values independent of supply and demand principles. Future works ought to propose sophisticated demand functions to determine optimal carbon trading prices. The source of pollutions and how to deal with any particular pollution source is one of the obscurities in this area, which opens another possible future work direction to make studies more applicable for real-world applications. Considering just a straightforward factor as the greening investment is not enough anymore.

In RSCs and CLSCs, the recycling and the collection effort are important decisions that need to be addressed in SSCC literature. Another fascinating issue in CLSC literature is the study of fairness concerns on both coordination and operational decisions. Implementing fairness into CLSC coordination requires advanced contract structures with coalitions and bargaining under different power structures. Furthermore, cooperative game-theoretic studies in the SSCC literature do not consider the non-economic attitudes of SC members.

Eventually, governmental legislation and intervention play a profound role in SSCC problems. Nonetheless, studies addressing this phenomenon in SSCC literature still need to be continued to fill the massive gap between academic efforts and business practice. Additionally, optimizing government decisions in problem modeling is a less-explored area that warrants further investigation.

5.3 Financial plus social plus environmental

TBL approach is primarily applied in qualitative sustainability studies, but they are rarely utilized in quantitative efforts, especially within the context of SSCC problems. Only in recent years, some academics (Heydari & Rafiei, 2020; Qian et al., 2020) have shown interest in examining all aspects of sustainability and their interactions in a single problem setting. There is a thin literature body in SSCC literature addressing all three pillars simultaneously. The authors prefer analyzing the pairwise interactions of sustainability pillars mainly due to avoiding to exert more complexity to mathematical models. Besides, theoretical, empirical, and analytical research opportunities seem to be neglected in this area. Surprisingly, the number of qualitative analytical research combining all three pillars of sustainability is not much as the pair-wise interactions of these pillars. This intact research avenue shows promising potential for further investigations. Moreover, the need to include culture as the fourth pillar in addition to TBL is an emerging topic. The exploration of the Quadruple Bottom Line (QBL) approach in prescriptive SC models is an emerging field (Ülkü & Engau, 2021; Ülkü & Mansouri, 2023).

5.4 Managerial insights

Main managerial insights drawn from the current review can be summarized as follows:

- *Enhanced Coordination in Real-World Settings*: Developing models suitable for complex real-world situations is absolutely essential for future researchers to follow.
- *Decision-Making amid Uncertainty:* Recent explorations in this area indicate that there are opportunities to make more informed decisions despite uncertain conditions.
- *Competitive Dynamics Matter:* SC operations could benefit from both vertical and horizontal competition while sustainability can be used as a competitive advantage in SSCC problems.
- *Clarified CSR and Sustainability Concepts Matter:* Defining CSR and other sustainability-related concepts within the context of an organization and providing real-world manifestation of these terms would enhance the effectiveness of CSR initiatives.
- *Beyond Two-Echelon Supply Chains:* Most of the existing literature focuses on two-echelon SCs. Real-world implications require more complex structures and intricate relationships among SC members.
- *Balancing Profit and Environmental Costs:* Although pursuing sustainability may initially incur costs, it can also stimulate consumer demand and willingness to pay. Balancing profit-oriented goals with environmental considerations is expected to maximize long-term benefits.
- *Risk-Aware Decision-Making:* Implementing risk-sensitive approaches like VaR, CVaR, and mean–variance analysis helps to better understand the potential impact of risk.

- *Acknowledging new solution methodologies*: To overcome complexities of mathematical modeling to reach optimal solutions, utilization of data-driven methods and machine learning approaches can be helpful.
- *Multidisciplinary Integration:* Sustainability requires a multidisciplinary approach. Aligning financial, social, and environmental goals within the SC needs a comprehensive strategy that effectively addresses practical challenges.

6 Summary and conclusion

Over the last decades, sustainability has gained undeniable popularity among academia and practitioners. This study represents an extensive literature review on the SSCC problems and explores key concepts of coordination in SSCs, searching for research gaps, possible future research directions, and principal research streams in this area. Motivated by the United Nations' Sustainable Development Goals (SDGs), the importance of sustainability, and inspired by the three pillars of sustainability, the existing literature is investigated and classified. Studies are selected based on their relevance to the coordination problems and sustainability considerations. All the proposed analyses are built on selected papers from prominent journals since the early 2010s. To the best of the current authors' knowledge, the number of studies conducted before this time is negligible, although in some cases, the origins of these studies can be traced back to the early 2000s and even earlier. In the first attempt, over 200 papers were identified, and from this group, the most relevant and profound efforts were thoroughly explored and summarized into well-structured literature review tables. In each subsection, essential properties of (1) coordination problem, (2) SSC, and (3) issues arising from their integration are identified. SC network structure, number of echelons, SC members, the possibility of direct channels, SC decisions, and research questions/motives are pointed out as the key elements of each paper. Integration level on operational decisions, coordination mechanism, and contract types (if applicable) are analyzed as indispensable features of a coordination problem. Finally, sustainability considerations in those studies are clarified.

The research model used to conduct the current literature review has certain limitations. Firstly, the scope and selection criteria were the primary concern where it could result in a bias toward the survey and potentially lead to the omission of relevant studies. To address this, the authors broadened the search criteria and collaborated with domain experts to adopt a more comprehensive approach. Secondly, there was a risk of academic bias, as the review primarily focused on academically published papers, potentially excluding valuable insights from industry reports. To mitigate this, during the initial stages of the review process, gray literature and industry reports were also explored to ensure that the presented structure includes the key aspects of SSCC problems. Lastly, there was a possibility of temporal bias, as the review may not fully represent the latest developments. To mitigate this, the authors confined their findings to a specific time horizon.

According to the results, the SSC's coordination motives are boosted through consumer awareness and governmental policies. These motives are often interpreted in terms of profitability in SCCC literature. The research gap analysis demonstrates the existence of strong research potential in this field because of two main reasons; first, the existing literature body is too thin to cover the basics of the SSCC problems, and second, academia and practitioners' attention has been boosted toward this issue in recent years. CEA alongside

governmental policies has led SC managers to consider sustainability as a competitive advantage. Some researchers believe that sustainability considerations are becoming a mandatory aspect of SCs. Overall, research on SSCC drivers and barriers reveals a growing trend in applying different coordination mechanisms and enhancing SC profitability in pursuing environmental/social performance elevation. This study concludes by arguing possible future research avenues, focusing on novel emerging topics, multidisciplinary perspectives, modelling approaches, and practical development opportunities.

Declarations

Conflict of interests The authors have no relevant financial or non-financial interests to disclose.

Appendix: Abbreviations

See Tables 8, 9 and 10.

Table 8 Expressions, abbreviations, and concepts

Entity name	Abbreviations
Decision variables	
Abatement level	AbateLvl
Advertisement, sales promotions and low-carbon promotions	Adv
Buyback price	BB
Collecting investment	C.Inv
Collection price	C.P
Collection rate	C.R
Discount value	Disc
Donation size	DS
Emission reduction	EmRd
Energy-saving efforts	Egy
Green innovation level, Greening level, Greening effort	GrLvl
Green marketing	GMC
Licensing fee	Lic
Order quantity	OQ
Price	P
Process development level	Prcs-dev
Recycling fee	REC
Recycling rate	Rcy
Return credit	RetC
Warranty period	Wrty
Wholesale price	WSP
Other expressions	
Closed-Loop Supply Chain	CLSC
Closed-Loop Supply Chain Management	CLSCM
Collaboration	Coll
Collecting effort	Coll.E
Competition	Comp
Consumers' environmental awareness	CEA
Consumers' social awareness	CSA
Cooperation	Coop
Cooperative game theory	CGT
Coordination	Coor
Green supply chain	GSC
Green supply chain management	GSCM
Not Applicable, Not Available	N.A
Reverse Supply Chain	RSC
Reward penalty scheme	RPS

Table 8 (continued)

Entity name	Abbreviations
Sub-game perfect equilibrium	SPE
Supply chain	SC
Supply chain coordination	SCC
Supply chain management	SCM
Sustainable supply chain	SSC
Sustainable supply chain coordination	SSCC
Sustainable supply chain network design	SSCND
Triple bottom line of sustainability	TBL
Variable-weighted Shapley value	VWS

Table 9 Entity abbreviations

Entity name	Abbreviations
Distributor	D
Firm	F
Focal company	FC
Government	GOV
Manufacturer	M
Remanufacturer	RM
Retailer	R
Supplier	S

Table 10 Contract abbreviations

Contract name	Abbreviations
Bilateral cost-sharing	BCS
Bivariate cost-sharing	BiCS
Carbon emission reduction cost-sharing	CCS
Co-op advertising and emission reduction cost sharing	CA-ERCS
Cooperative Advertising	CA
Cost sharing	CS
Cost-tariff	CT
Energy-saving cost-sharing	ECS
Government subsidy sharing and cost sharing	GSCS
Greening-cost sharing	GCS
Hybrid greening cost sharing and revenue sharing	HGRS
Increasing fee contract	IF
Linear price-discount sharing	PDS
Multilateral compensation-based wholesale price policy	MCBWP
Multi-objective collaborative decision-making model*	MOC
Non-linear programing*	NLP
Price discount	PD
Price-only	PO
Quantity discount	QDS
Return contract	RT
Reward penalty scheme	RPC
Revenue and greening-cost sharing	RGCS
Revenue and promotional cost-sharing	RPS
Revenue, production and marketing cost-sharing	RPM
Revenue, production cost, and CSR cost-sharing	RPC
Revenue-and-expense sharing	RES
Revenue-Cost sharing	RC
Revenue-Responsibility-Cost sharing	RRC
Revenue-sharing	RS
Revenue-sharing with subsidy on emission	RSS
Side payment	SP
Three-party compensation-based contract	3PC
Transfer payment mechanism	TPM
Two-part tariff	2PT
Vendor Managed Inventory with Consignment Stock	VMI-CS
Wholesale price	WSP
Wholesale price-bilateral participation	WP-BP
Wholesale price-revenue sharing	WP-RS

*Not a contract but an optimization technique

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