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Overcoming barriers to cross-sector collaboration in circular supply chain management: a multi-method approach

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A R T I C L E I N F O

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A B S T R A C T

Economies are transitioning from a linear to a circular model to address global issues such as resource extraction, environmental degradation and waste generation. Cross-Sector Collaboration (C-SC) is an effective means to use resources in a way that is mutually beneficial and integrates sustainable practices into the value chain. The zero-waste aspiration of companies can be achieved through Circular Supply Chain Management (CSCM). Existing literature supports research initiatives in CSCM, but how C-SC influences CSCM is still unexplored. Moreover, the barriers to C-SC for CSCM are untouched and the strategies to overcome these barriers are unmapped. This study fills this gap, assesses the barriers to C-SC for CSCM and suggests a strategic roadmap to overcome these barriers. The study was conducted in three different phases employing a multi-method approach of Agglomerative Hierarchical Clustering (AHC), Fuzzy Delphi and Fuzzy Decision-Making Trial and Evaluation Laboratory (F-DEMATEL). The results reveal that governance barriers and contextual barriers are causal and influence the other barriers. There is a need to enhance the capacity and optimum resource utilisation for developing circular supply chains; it is possible to facilitate CSCM practices only through collaborative efforts across sectors. The study also highlights that government policymaking and regulation, collaborative value capture model and Industry 4.0 technologies are the most effective strategies for managing C-SC for CSCM. This study contributes to stakeholder theory and resource-based view theory by explicating collaboration among cross-sector stakeholders and highlighting the significance of resource optimisation through waste management.

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1. Introduction

The 'take, make and dispose' linear model is an economic dead-end, leading to shortages of raw material, high costs and volatility (Patwa et al., 2021). Linear economies struggle with unsustainable supply chains and critical issues such as climate change, waste generation, disposal and environmental degradation (Nandi et al., 2021). Thus, these economies are now seeking innovative models, frameworks and approaches to achieve a sustainable future (Morseletto, 2020; Dutta et al., 2021). The transition to a Circular Economy (CE) has been increasingly recognised as the better alternative, viewing waste as a raw material as opposed to the linear economic model (Islam and Huda, 2018; Cai and Choi, 2020; Burke et al., 2021; Yu et al., 2021). CE is a thought-provoking process for manufacturing and service organisations aiming to adopt and implement circular practices in their Supply Chain Management (SCM) functions for the development of sustainable, efficient and circular supply chains (Govindan et al., 2020; Yu et al., 2021). This process of integration of CE practices into SCM is termed Circular Supply Chain Management (CSCM) (Nasir et al., 2017; Farooque et al., 2019b; Zhang et al., 2021).

CSCM is a dynamic, hyper-connected network where all stakeholders are inter-connected and inter-dependent (Wieland, 2021); knowledge exchange and collaboration take place to achieve a common goal. In CSCM, organisations collaborate within and across sectors to maximise the value of goods/materials (Chauhan et al., 2021). CSCM helps organisations achieve resource efficiency and profitability while diminishing negative environmental, social and economic impacts. CSCM aims to develop circular supply chains with an aspiration to achieve zero waste. In comparison with a linear supply chain, a closed-loop supply chain improves environmental performance by bringing back goods and packaging materials to the producer for value recovery (Farooque et al., 2019b). However, in a closed-loop supply chain, the extent of value recovery is often limited because it does not allow secondary supply chain or any other member to be involved (Farooque et al., 2019b). A substantial amount of waste is generated in a closed-loop supply chain as it is rarely feasible to recycle/reuse all unwanted items within the same supply chain. Thus, circular supply chains provide an opportunity for development by recovering value from waste through collaboration within the same sector or across sectors (Farooque et al., 2019b).

Cross-Sector Collaboration (C-SC) is an alliance of organisations, government, non-profit, philanthropic and other sectors determined to utilise their diverse perspectives and resources in a joint approach toward a societal problem (Al-Tabbaa et al., 2019). C-SC is based on industrial symbiosis and can act as an effective way to shift toward a CE by recovering value from by-products and waste. Industrial symbiosis originated from the Kalundborg symbiosis of Denmark; the synergistic interaction encourages one company's waste to be used as an input by another (Turken and Geda, 2020). A C-SC based on industrial symbiosis has the aim of developing circular supply chains that generates zero waste. Moreover, this collaboration is not limited to resource providers or consumers, but also involves third parties who practise recycling and other related work (Turken and Geda, 2020; Farooque et al., 2019b). There are two types of resource flows present in circular supply chains, primary and secondary. The forward flow of goods constitutes the primary resource flow, whereas goods that are recycled, retained or reused are secondary resource flows (De and Giri, 2020; Xiao, et al., 2020).

CSCM practices are implemented in some developed countries, e.g., Germany, France and the UK (Yu et al., 2021). However, in India, it is still at a nascent stage due to a lack of facilitating support and policies (Dutta et al., 2021). Currently, India's resource extraction of 1580 tons/acre is 251% higher than the world average of 450 tons/acre (MOEF, 2019). India recycles 20% of its consumables compared to Europe's 70% (MOEF, 2019; Wang et al., 2021). India stands in third place for the emissions of greenhouse gases, accounting for 9.2 % of total global emissions. India aspires to be a global manufacturing hub with the expectation that raw material consumption will significantly increase. Increasing consumption in a linear model can cause severe ecological damage with economic and social complications. With the adoption of CE practices in India, an annual benefit of 40 lakhs crores, or US$ 624 billion by 2025 can be achieved (Lahane and Kant, 2021). In addition, greenhouse gas emissions can be reduced by 44% along with a significant reduction in pollution. This can create economic and environmental benefits for society (Ellen MacArthur Foundation, 2016). To achieve this goal, there needs to be a change in the thinking process to incorporate circularity in SCM practices on a path to zero-waste (Farooque et al., 2019a).

Currently, developing nations are transforming to CE in an effort to address major challenges in society. The challenges facing developing nations are distinct as compared to developed nations; however, C-SC can bring together a diverse group of sectors to find solutions for everyone. Therefore, the role of C-SC becomes more important in developing and emerging economies where resources and the knowledge base can be limited. Previous studies have assessed value creation using C-SC (Vestergaard et al., 2020) and dimensions of circular supply chains. The study by Morseletto (2020) showed effective governance and policy strategy through C-SC may provide the impetus toward a CE. In developed countries, CSCM research initiatives have been increasing (Yu et al., 2021) whereas research has been limited to only conceptual frameworks of CSCM in developing countries (Farooque et al 2019b). The Indian context is least prepared for CE implementation (Farooque et al., 2019a); Currently, India lacks in-depth research in the area of CSCM practices. There needs to be more studies into quantitative models that reveal inter-relationships among barriers to C-SC; developing countries must learn how to overcome these barriers.

In the past few years, C-SC has become a significant approach to synthesize critical functions and explore inter-dependencies, resources, information and capabilities (McDonald and Young, 2012; Chen et al., 2019). Manufacturing processes to enable CE highlight how to remove waste and create value (Urbinati et al, 2017; Blomsma and Tennant, 2020). It is not easy to develop products that last, are easy to reuse or recycle and are profitable. But based on a collective approach, design teams, with help from other company departments, have delivered resource efficient products with high customer satisfaction. For example, increased collaboration on medical equipment manufacturing enabled the collection and refurbishment of used devices to fulfil the needs of underserved customer sectors in emerging economies (Mckinsey, 2016). Although C-SC has become a critical governance strategy, there are still important knowledge gaps. Moreover, C-SC needs to be managed cautiously. Previous studies have shown that C-SC is complex

Table 1
The search criteria.

Search terms	Initial search
'Circularity' AND 'Supply chain management'	33
'Cross sector collaboration'	554
'Circularity, supply chain management' AND 'cross sector collaboration'	49
'Strategies' AND "Cross sector collaboration"	123

in nature and outcomes are only achieved after great persistence (Bryson et al., 2015). To address societal problems in developing nations where institutions are weak and lack capacity, C-SC can develop a raft of opportunities. There is a need to explore the potential of C-SC for CSCM in developing countries like India and to identify the major barriers of adopting CSCM practices. In addition, there is a need for a strategic roadmap for future circular supply chains. This study proposes the following research questions (RQs):

RQ1: What barriers restrict C-SC for CSCM in India?

RQ2: What are the inter-relationships among these barriers to C-SC existing in India?

RQ3: What are the strategic alternatives to reduce the impacts of the barriers to C-SC for effective CSCM practices?

The study has utilised three different phases employing a combined approach of Quantitative and Qualitative (Qual-Quantitative) methods. Agglomerative Hierarchical Clustering (AHC) was used in phase one to reduce the number of barriers. The second phase included a Fuzzy Delphi application to validate and categorise the barriers followed by Fuzzy DEMATEL for the cause-and-effect relationships. A sensitivity analysis was also performed to check the robustness of the model. In the third phase, a focus group discussion was conducted to validate the results and determine the most appropriate strategy for overcoming each barrier.

This study extends the stakeholder theory, highlighting the significance of collaboration among stakeholders and their symbiotic relationship. Further, it extends the theory to show the successful adoption of circular practices based on stakeholder collaboration and their symbiotic relationship. Collaboration across sectors can develop a common vision and policy framework derived from stakeholder theory and resource-based theory to develop circular supply chains Friedman and Miles (2002). The study on C-SC is associated with inter-organisational relationships that include the resource-based view (Jabbour et al., 2019), stakeholder theory (Freeman, 1994) and resource dependence theory (Murphy and Arenas, 2010). This enriches understanding of the significance of collaboration across sectors of using waste as a resource in the formation of circular supply chains. To identify the barriers to C-SC for CSCM and devise a strategic roadmap using stakeholder theory and resource-based view, the following objectives were set:

- To investigate the barriers of C-SC for CSCM.
- To understand the cause-effect relationships among the barriers and build an influential network relationship map.
- To suggest strategic recommendations to overcome the barriers in C-SC for CSCM.

Section 2 of the paper elaborates on the literature related to C-SC and CSCM and the theoretical foundation of the study. Section 3 discusses the research methods with an explanation of those methods adopted. Section 4 presents the proposed research framework. Section 5 discusses the findings of the research. Section 6 highlights the strategy roadmap to reduce the impacts of the barriers related to C-SC for CSCM. Finally, section 7 details the conclusions, limitations and future directions for research.

2. Literature review

The pertinent published literature was explored on C-SC, CE and strategies for C-SC. The databases "Scopus" and "Web of Science (WoS)" were used. The extraction of relevant papers was achieved through the steps shown in Table 1. The search was related to "circular supply chain management," "barriers to cross sector collaboration," "cross sector participation," "barriers to cross sector collaboration," "circular supply chains" and "strategies for cross sector collaboration". The multiple keywords were searched for appropriate articles. The search was limited to journal articles from "2010–2021". The data was collected in March 2021 using the criteria shown in Table 1.

759 articles were found in the first search. The first filter excluded theses, reports, technical papers, editorials and magazines. Further, it excluded conference proceedings, book series and trade publications. The second filter excluded articles that were not in English, resulting in 297 articles. The third filter excluded articles based on duplicate publications. After the third iteration, 121 articles were left. The fourth filter included only those articles that were related to the research questions of the study. Finally, 75 articles were chosen for the study.

2.1. Theoretical foundation

The current study is based on the stakeholder theory's notion suggesting that an organisation's success is dependent on the relationship with its stakeholders. This implies that successful organisations consider the relationship with the stakeholders that they affect as well as those that affect them (Freeman, 1994). By adopting C-SC, inter-relationships among stakeholders such as business, government and Non-Governmental Organisations (NGOs), are enhanced, amplifying the overall effectiveness of supply chains. The barriers identified in the study are assessed by their potential impact to limit stakeholder collaboration to develop CSCs. Stakeholder inter-relationships are a key element in developing C-SC and hence the barriers to it need to be evaluated. Stakeholders include all

Table 2
List of barriers to C-SC for CSCM.

S. No.	Barriers	Brief Description	References
1	Misaligned interests of individuals across sectors; unenlightened self-interest	Individuals can become misaligned when their interests do not match. The mismatched interest may hamper C-SC to develop CSCM.	Murphy and Arenas, 2010; Bode et al., 2019; Loosemore et al., 2020
2	Temporal dynamics of technology difference	Differences exist in the temporal dynamics of technology among partners; this restricts ability to collaborate for CSCM.	Al-Tabbaa et al., 2019
3	Lack of trust among cross-sector collaborators	Partners have trust issues in relation to other sectors. The perceived trust varies from organisation to organisation and thus limits collaboration and development of shared goals toward CSCM.	
4	Diverse institutional logics across sectors	Distinct broader belief systems shape cognition and behavior of cross sector collaborators to adopt CSCM practices.	Bryson et al., 2015; Tulder and Keen, 2018; Hesse, 2019
5	Lack of integrated planning and management practices framework	Sectors are restricted by their independent planning and management practices and are thus unable to develop integrated planning toward CSCM.	De Sousa Jabbour et al. 2018 ; Moktadir et al. 2018
6	Monitoring performance within multiple contexts	Stakeholders monitor performance in different contexts creating complexity in developing C-SC for CSCM	Shankar et al. 2018
7	Incompatibility with the corporate "immune system"	Incompatibility exists in incentives, designs and methods of profit-oriented organisations with government and not-for-profit structures. There are differences in the compatibility of sectors that restrict them from adopting C-SC for CSCM.	Weber et al., 2021
8	Organisational norms and culture	Organisational norms and culture restrict stakeholder competencies and force them to focus on their interests, thus impacting the decision not to collaborate across sectors for CSCM.	Babiak and Thibault, 2009
9	Internal bureaucracy	Administrative structures are complex and overlap; it becomes difficult to collaborate with other sectors for CSCM.	Bryson et al., 2015
10	Risk of information loss; information insecurity	Employees and managers do not know what information can be shared to support collaboration for CSCM and thus worry about information loss.	Loosemore et al., 2020
11	Loss of control over operations	Different sectors do not collaborate as they fear losing control over their operations. Their fear is a barrier in their C-SC for CSCM.	Bryson et al., 2015; Compagnucci and Spigarelli, 2018
12	Lack of common vision and policy framework	Due to a lack of vision, management is often reluctant to support activities for sustainable operations. It may be difficult for organisations to develop one policy and vision across sectors as their business operations, models and processes are different.	Babiak and Thibault, 2009
13	Competition vs. collaboration	Competition creates tension among collaborators that leads to frustration and violates the 'true spirit' of collaboration.	Babiak and Thibault, 2009; Hafezalkotob, 2017; Guo, et al., 2020
14	Absence of system standardisation for performance management	Lack of pre-defined systems to measure the impact of collaboration as well as lack of parameters to evaluate costs and savings for developing CSCM.	Bode et al., 2019
15	Inbuilt organisational resistance	The resistance to embrace change in an organisation after C-SC adoption for CSCM restricts the ability to move away from traditional approaches.	Bode et al., 2019
16	Less demand/ acceptance for superior technologies	Due to lower awareness, the demand for superior technology is less in developing nations. It restricts collaboration across sectors for implementing CSCM.	Kazancoglu et al., 2020
17	Lack of adaptive governance structures	The economy is still lacking an adaptive structure to support C-SC for CSCM.	McDonald and Young, 2012; Lahane et al., 2020
18	Lack of legitimacy	Competition exists to acquire scarce resources.	McDonald and Young, 2012; Chen et al., 2019
19	Risk management approaches	Different sectors have their own autonomous approaches to perceive and mitigate risk. Thus, it is difficult to manage among partners/ collaborators across sectors.	Fattahi and Govindan (2018)
20	Government regulations	Government regulations have the potential to block an organisation's ability to collaborate across sectors.	Babiak and Thibault, 2009
21	Limited knowledge/experience	Lack of experience/ knowledge about how to facilitate C-SC for developing CSC chains.	Loosemore et al., 2020
22	Absence of commitment at top-level management	Due to lack of commitment from top-level management for sustainable practices, the focus of the organisation is narrowed, restricting the potential to collaborate for CSCM.	McDonald and Young, 2012
23	Lack of power asymmetry	There is a mismatch between the powers of partner organisations because of different levels of resources. The difference in their power delegation in the new collaborative environment acts as a barrier for C-SC for CSCM.	Babiak and Thibault, 2009; Herlin, 2015
24	Low levels of transparency and poor quality of disclosures	Different stakeholders may be reluctant to share information and disclose information; this may act as a barrier for C-SC for CSCM	Bryson et al. 2015; Ashraf et al. 2017
25	Isomorphic institutionalism	The pressure to follow existing institutional culture sometimes limits the organisation to use their skills and knowledge in the area where	Heuer, 2011

(*continued on next page*)

Table 2 (*continued*)

S. No.	Barriers	Brief Description	References
		investment has been made. This makes the organisation bound to their current processes and closed to a collaborative approach.	
26	Duplication of responsibility and authority	Cross sectors may have duplication in responsibilities of individuals that makes them uninterested in being part of a collaborative circular network.	Heuer, 2011; Stadtler and Karakulak, 2020
27	Lack of social movements	Social movements are required to develop relationships across sectors to form the bonds needed for collaboration to achieve mutually beneficial outcomes on social issues.	Heuer, 2011; Klitsie et al., 2018

supply chain partners involved from the manufacturing process to end-of-life. Stakeholder theory proposes that collaboration across sectors will be a key to the successful implementation of CSCM in organisations (Wang et al., 2021). Stakeholder theory explores the implications of contentious relationships between stakeholders and organisations by introducing compatible/incompatible interests and necessary actions as additional attributes Friedman and Miles (2002). This study assesses mutual trust and aligned interest from a collaboration perspective.

Resource based view (RBV) was developed in 1957 by Selznick. This theory suggests that an organisation's competitive advantage is dependent on its capacities and resources required. The organisation develops its competitive advantage through assets in the form of valuable resources and capacities, then formulating appropriate strategies (Ray et al., 2004). The basic assumption of this theory proposes that organisation performance can be explained on the basis of resource management. C-SC in circular supply chains may help in creating competitive advantage for the firm as it aims toward zero waste. This study extends RBV theory as C-SC needs a common vision on resource extraction and zero waste. Resource availability is a global issue and circular supply chains can help optimally use scarce resources. RBV helps to explain why some firms perform better than others by fundamentally analysing internal resources and capabilities as sources of sustainable competitive advantage (Ramanathan et al., 2016). Based on elaboration of this theory, the authors point out;

a) RBV and stakeholder theory help to identify C-SC among firms based on resource utilisation and their inter-dependency on each other (Kraaijenbrink et al., 2010).
b) RBV helps in underpinning the potential of resource sharing and developing competitive advantage through C-SC.
c) Stakeholder theory contributes to understanding the role of integration among stakeholders, leading to innovative business models that can achieve sustainable goals through scaling up relevant resources.
d) RBV and stakeholder theory contribute to developing an integrated framework that supports each other's efforts toward development of circular supply chains (de Sousa Jabbour et al., 2018)

2.2. *Cross-Sector collaboration (C-SC) for circular supply chain management (CSCM)*

The nature and characteristics of C-SC are both underspecified and contested. The definition of C-SC is adapted from Hofmann and Jaeger-Erben (2020). They suggest C-SC happens when independent actors from different sectors collaborate and negotiate to share their resources and develop their core capabilities. C-SC involves long-term relationships with high levels of inter-dependency, risk sharing, common goals and a necessity to collaborate for mutual benefit (Brown et al., 2021). Previous studies have encouraged "blended" and "shared" value concepts as mechanisms for developing new forms of social value, joint impacts and a common agenda that requires a clear plan and open communication (Kania and Kramer, 2011; Dentoni et al., 2016). Policy studies also include the concept of network governance to reflect the collaborative approach and increased emphasis on the role of private players in spreading awareness (Bozeman and Johnson, 2015; Wang, et al., 2020). Collaboration is seen as key to solving our pressing global problems, as reflected by UN Sustainable Development Goals (SDGs) 17, focused on partnerships to deliver the other 16 SDGs.

CSCM is the incorporation of circular thinking into SCM and its surrounding ecosystems. It has a zero-waste mission delivered through innovative business models and supply chain functions (Farooque et al., 2019b). In CSCM, all stakeholders integrate the CE concept into the supply chain process, leading to innovative business models to achieve sustainable goals through scaling up relevant resources (Farooque et al., 2019b; Fehrer and Wieland, 2021). Implementation of CSCM may bring challenges in scaling up materials across multiple stakeholders; these challenges include culture, governance, skills and technology (Govindan and Hasanagic, 2018; Harland, et al., 2021).

C-SC is an emerging research area (deBruin et al., 2017). The literature on C-SC to date has elaborated on motives for collaboration or partnership; few studies have dealt with how such collaboration can create value. Previous studies have assessed the CSCM concept but not how C-SC can influence it. Yu et al (2015) conducted a study to explore barriers to implementing industrial symbiosis in an industrial park using DEMATEL; Mangla et al (2018) explored the barriers to circular supply chains of the automotive industry from an Indian perspective using integrated Interpretive Structural Modelling (ISM); Farooque et al. (2019a) identified and assessed barriers to circular food supply chains in China using Fuzzy DEMATEL; A review paper by Turken and Geda (2020) recognised collaboration among third parties who practise recycling and other related businesses; Morseletto (2020) showed that effective governance and policy strategy through C-SC may provide the impetus toward a CE, but no study has been conducted on how to overcome barriers to C-SC employing a multi-method approach. The literature on C-SC has mostly concentrated on single cases of collaboration for specific

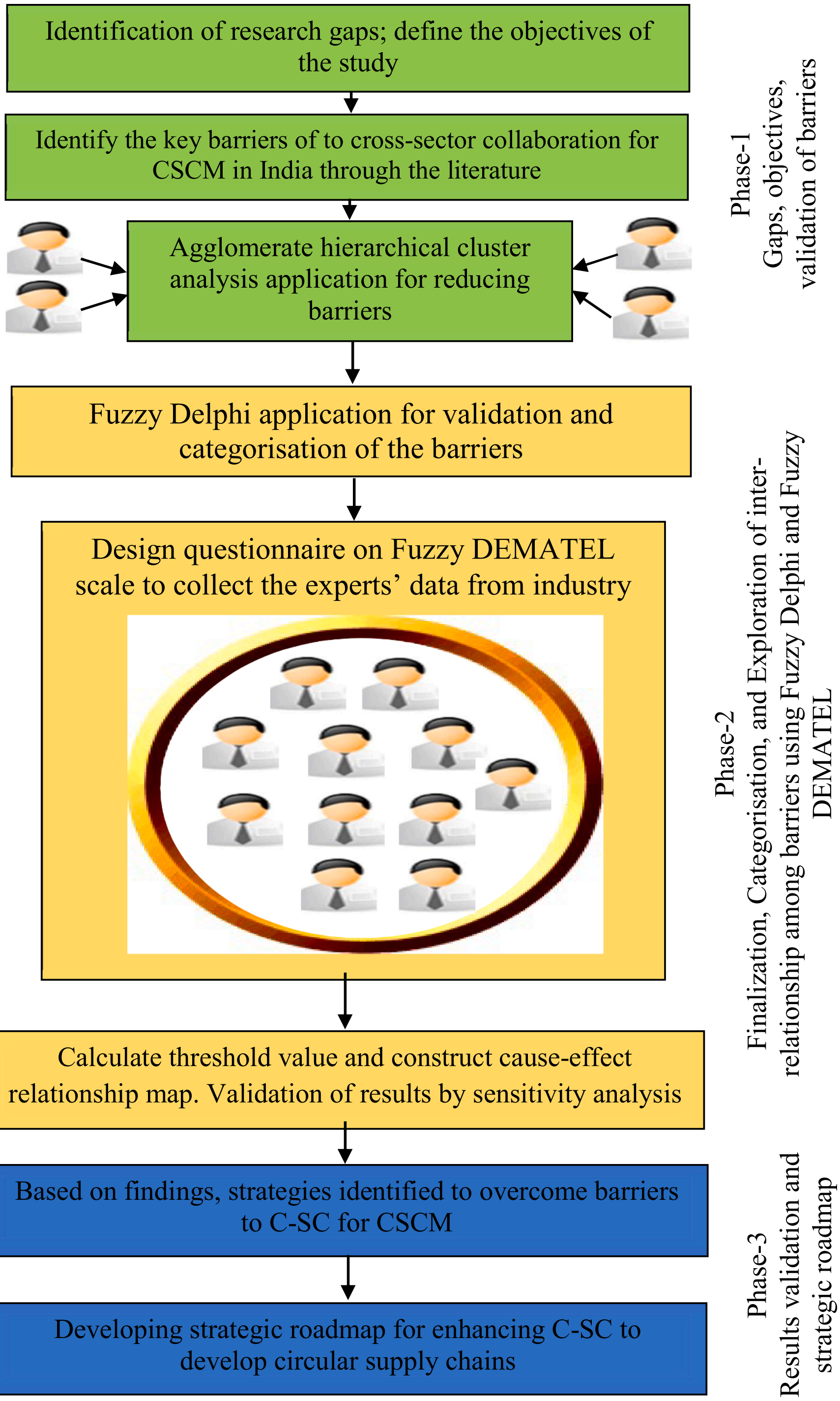

Fig. 1. Methodology framework.

objectives. This is the first study to focus on the barriers to C-SC and supply chains for adopting and implementing CSCM practices and evaluating strategies to enhance collaboration across sectors.

This study contributes to RBV and stakeholder theory by exploring the significance of C-SC in developing an effective association among stakeholders and treating waste as a useful resource for developing circular supply chains in the future. This study suggests that organisations must understand the emergent needs of an integrated framework and practices that support each other's efforts toward circularity, this is aligned with previous research (de Sousa Jabbour et al., 2018). RBV theory suggests that firms can integrate to create and sustain competitive advantages through their rare, inimitable and non-substitutable resources. This study has identified barriers that have been experienced in India and other nations. The barriers have been assessed in an Indian context according to their relevance and impact. The inter-relationships among barriers contribute to developing appropriate strategies for each barrier. A total of 54 barriers (Appendix A Table A1) were initially identified, but after employing AHC, 27 barriers were finalised as shown in Table 2 (ref. see Section 4.1 for more details).

3. Research methodology

A three-phase framework was followed as shown in Fig. 1. The study was complex and conducted in three phases where results from each phase were validated before moving on.

Current literature was explored during the first phase of this study to identify the barriers to C-SC. AHC was applied to reduce the number of barriers. The second phase included a Fuzzy Delphi application to validate and categorise the barriers followed by Fuzzy DEMATEL for the cause-and-effect relationships. Also, the Fuzzy DEMATEL results were validated by sensitivity analysis. In the third phase, a focus group discussion was conducted to validate the results of Fuzzy DEMATEL and determine the most appropriate strategy mapped with each barrier. The elaboration of methods undertaken is discussed in the subsequent sub-sections.

3.1. Agglomerative Hierarchical clustering (AHC) analysis

AHC is a data mining technique. It is the most common method used to group objects in clusters based on their similarity. The algorithm starts by treating each object as a single cluster; these are grouped as it moves up in the hierarchy.

The Ward's method is used for clustering. In this method, the sum of the squared errors is used as the objective function and grouping is performed based on the optimal value of the function, shown in equation (1).

$$SSE(i) = \sum_{i}^{m}\sum_{i}^{m}(xij - \overline{x}j)^2 \tag{1}$$

Where m is the number of barriers being evaluated and n is the total number of instances obtained for every barrier; $\overline{x}j$ is the mean of all the instances for a barrier.

Through this method, clusters are formed to minimise the total variance in the cluster; the factors are chosen incrementally so that there is increase in variance within the cluster after grouping.

$$D(a,b) = SSE(a,b) - (SSE(a) + SSE(b)) \tag{2}$$

A minor increase in the SSE will indicate that all barriers in the cluster are close to the cluster mean and a high degree of similarity exists. The following steps are implemented to reduce the number of barriers in the study.

1) The process starts with a collection C with single clusters; each cluster has one barrier. The steps are recursive and run to obtain n-1 clusters then n-2 clusters and so on, until all barriers are grouped into one.
2) Find a pair of clusters which are most similar from the collection; that is the pair for which $D\ (C_a,\ Cb)$ is least.
3) Merge the clusters Ca and C_b to form a new cluster C_{a+b}
4) Remove C_a and C_b from the collection and add C_{a+b} to the collection.

With the following algorithm, the barriers are clustered based on their similarity to minimise variance between the barriers in the cluster. The illustration of results is shown through a dendrogram for cluster visualisation. The dendrogram is used as a tool to develop the list of the most critical barriers to C-SC. The final 27 barriers are shown in Table 2 for validation using the Fuzzy Delphi method.

3.2. Fuzzy Delphi method

The Delphi method may be defined as a qualitative method to collect information in a specific area (Hsu et al., 2010). This method focuses on knowledge rather than people. Fuzzy based Delphi introduced by Ishikawa (1993) is more accurate as it captures the vagueness in data. The application of this method has been made in several areas such as performance; performance of green SCM (Bhattacharya et al., 2014; Li et al., 2020); selection of technology (Hsu et al., 2010) and logistics (Bouzon et al., 2016). The current study has applied Fuzzy Delphi to obtain the joint decision making that aims to assess the barriers in C-SC for CSCM. The process is elaborated in the following steps:

Step 1: This includes the extraction and identification of barriers to C-SC for CSCM. The literature is tabulated related to barriers to C-SC for CSCM (Table 2).

***Step 2*:** The barriers are identified and the information documented is shared with experts. With the help of a linguistic scale, the barriers are evaluated. Assuming fuzzy number z_{ij} to be the j^{th} evaluation of barriers of the i^{th} expert of n experts

$$z_{ij} = (a_{ij}, b_{ij}, c_{ij}) fori = 1, 2, 3, \cdots, nandj = 1, 2, 3, \cdots, m \tag{3}$$

Then, the fuzzy weights of barriers a_j are given as follows: $a_j = (a_j, b_j, c_j)$

Table 3
Linguistic labels.

Linguistic terms	Triangular fuzzy numbers
Very High (VH)	(0.9, 1.0, 1.0)
High (H)	(0.7, 0.9, 1.0)
Medium High (MH)	(0.5, 0.7, 0.9)
Medium (M)	(0.3, 0.5, 0.7)
Medium low (ML)	(0.1, 0.3, 0.5)
Low (L)	(0, 0.1, 0.3)
Very Low (VL)	(0, 0, 0.1)

$$a_j = \min(a_{ij}), b_j = \left(\prod_{i=1}^{n}(b_{ij})\right)^{1/n} c_j = \max(c_{ij}), where, i = 1, 2, \cdots, n, j = 1, 2, \cdots m \tag{4}$$

Step 3: This final step uses mean method S_j obtained from eq. (5).

$$S_j = (a_j + b_j + c_j)/3 j = 1, 2, \cdots..m \tag{5}$$

The selection of the final barriers is dependent on the threshold value (α) calculated by

a) If $S_j \geq \alpha$, accept the barrier; if $S_j < \alpha$, reject the barrier.

3.3. Fuzzy DEMATEL

The decision making in the context of C-SC for CSCM is multi-faceted. The complexities are due to the ambiguity in the data due to the involvement of multiple stakeholders, human subjectivity in judgment and linguistics. Thus, fuzzy theory helps decision makers to clarify responses in crisp form under imprecise and uncertain situations. The Fuzzy DEMATEL method extends the practicality of the DEMATEL method for group decision making in a fuzzy environment (Li et al., 2019; Yavas and Ozkan-Ozen, 2020). The steps followed in the process are described below.

Step 1: Identification of the goal and formation of the group of experts

The decision-making process is complex and consists of several actions - identification of goals, collection of information and enlisting the possible number of alternatives, evaluation of the alternatives, selection of the best alternative, monitoring of the performance and attainment of the goals. Thus, the process starts with the identification of the goals and formation of the expert panel for information collection (Venkatesh, et al., 2018).

Step 2: Developing barriers for evaluation and framing the fuzzy linguistic scale.

The set of barriers is identified for evaluation in this step. However, the nature of causal relationships makes evaluation of the barriers complicated in many respects. To develop a model based on cause-and-effect group barriers, Fuzzy DEMATEL is applied in this study. To deal with ambiguity in the human assessment, linguistic labels are used {Very High, High, Medium High, Medium, Medium Low, Low, Very Low}; these are expressed in positive triangular fuzzy numbers as shown in Table 3.

Step 3: Aggregation of the decision makers' assessments

The expert group was asked to make assessments in terms of influence and direction. Hence, the initial direct-relation matrix Z = $[Z_{ij}]_{n\times n}$ can be obtained from the following equations. To obtain the crisp values, fuzzy responses are de-fuzzified and aggregated using equations (6) – (13).

$$xl_{ij}^{k} = (l_{ij}^{k} - minl_{ij}^{k})/\Delta_{min}^{max} \tag{6}$$

$$xm_{ij}^{k} = (m_{ij}^{k} - minl_{ij}^{k})/\Delta_{min}^{max} \tag{7}$$

$$xr_{ij}^{k} = (r_{ij}^{k} - minl_{ij}^{k})/\Delta_{min}^{max} \tag{8}$$

$$Where \Delta_{min}^{max} = maxr_{ij}^{k} - minl_{ij}^{k}$$

Compute left (ls) and right (rs) normalised values:

$$x1s_{ij}^{k} = xm_{ij}^{k}/(1 + xm_{ij}^{k} - xl_{ij}^{k}) \tag{10}$$

$$xrs_{ij}^{k} = xr_{ij}^{k}/(1 + xr_{ij}^{k} - xm_{ij}^{k})$$

$$x_{ij}^{k} = \left[x1s_{ij}^{k}\left(1 - x1s_{ij}^{k}\right) + xrs_{ij}^{k}xrs_{ij}^{k}\right]/[1 - x1s_{ij}^{k} + xrs_{ij}^{k}] \tag{11}$$

$$Z_{ij}^{k} = minl_{ij}^{k} + x_{ij}^{k}\Delta_{min}^{max}. \tag{12}$$

Integrating crisp values by

$$Z_{ij} = 1/p\left(z_{ij}^{1} + Z_{ij}^{2} + Z_{ij}^{p}\right) \tag{13}$$

Step 4: Establishment and analysis of the structural model

Based on the initial direct relation matrix Z, the normalised direct matrix X is obtained. Further, the total relation matrix is obtained by using the formula in eq. (14).

$$T = N(I - N)^{-1} \tag{14}$$

Using the horizontal axis (D + R) and the vertical axis (D - R), a causal diagram is obtained. The horizontal axis, ''Prominence,'' exhibits the level of importance, whereas the vertical axis "Relation," categorises the barriers into causal and effect group barriers. If the value of (D-R) is positive, the barrier is categorised in the cause group; if the (D-R) value is negative then the barrier is categorised in the effect group. Causal diagrams have the capacity to allow visualisation of the complex inter-relationships among barriers and provide insights for decision makers.

3.4. Sensitivity analysis

Based on the results obtained from Fuzzy DEMATEL, each criterion's weight is calculated. Kobryń (2017) proposed a method to determine the criterion weights as discussed below. The local weight of each sub-category is calculated using equations (15) and (16). The global weights of each barrier is computed by multiplying weights of barriers to C-SC with local weights.

$$T_{average} = \frac{(D + R) + (D - R)}{2} \tag{15}$$

$$W_i = \frac{T_{average}}{\sum_{i=1}^{n} T_i^{average}} \tag{16}$$

Equation (16) provides the weights of each criterion where $\sum_{i=1}^{n} W_i = 1$

4. Proposed framework and application

The methods discussed in the previous section are applied step by step as shown in Fig. 1. The phases are discussed below.

4.1. Phase 1: Identification and finalisation of barriers

A questionnaire was shared with 60 professionals from different industries. The objective was to find the absolute impact of 54 barriers to C-SC for CSCM (Appendix A Table A1). The value of Cronbach's Alpha obtained was higher than 0.80, indicating the reliability of the questionnaire. Since the number of barriers is large, making it tedious for respondents to assess the impact on the C-SC, it is reduced by AHC, a data mining technique. The clustering through dendrogram is shown in Appendix A, Fig. A1.

For the formation of an expert panel, a workshop on CE was conducted in March 2021 with>45 experts in the areas of CE, sustainability and green initiatives. The objective of the workshop was to bring the practitioners and academicians to one platform to share their challenges, best practices and resource mobilisation to enhance the transition to CE. The workshop was conducted using offline and online platforms. In the first round of invitations for the offline event, >100 e-mails were sent to directors, managers, entrepreneurs and government officers who had been exposed to CE practices. Out of 100 + experts, only 30 were able to participate. In the second round of invitations, 60 experts were invited but only 20 accepted. Professors from well-known universities in the UK, USA, Turkey and India were invited to an online panel discussion. Before the workshop, five experts withdrew and asked to join through an online platform. On the final day of the workshop, a total of 45 experts (offline) and 15 experts (online) were present for brainstorming and panel discussion. The experts were also grouped according to their expertise and knowledge about CE practices and C-SC. Out of 45 experts, 13 were selected to validate the identified barriers to C-SC. These experts were well versed in circular supply chains and had undertaken collaborative initiatives within their organisation. The identified list of 27 barriers with descriptions was shared with the 13 experts. Of the 13, two were from a government waste management organisation in India; three were from manufacturing firms in the area of sustainability; two entrepreneurs were from waste management and recycling; two experts were from academics in the area of CE and sustainability; three were from companies with sustainable manufacturing practices in the food

Table 4
Details of experts.

Expert Code	Designation	Age (In years)	Industry	Experience (In Years)	Domain
E-1	Sustainability Manager	> 40	Manufacturing	>12	Green supply chain; CE; Sustainability; Green vendor selection
E-2	Manager (CSR)	> 40	Manufacturing	>10	Social responsibility; Sustainability; Green supply chain management
E-3	Entrepreneur	>30	Start-up (Carbon footprints)	>5	Carbon emissions; Sustainability
E-4	Manager (Supply Chain)	> 40	Manufacturing	>15	Green supply chain management
E-5	Government Officer	> 40	Waste management	>15	Waste management
E-6	Government Officer	> 40	Planning commission	>15	Policy making
E-7	Entrepreneur	>30	Recycling	>5	Sustainability; Formal recycling
E-8	Manager (Sustainability)	> 35	Services	>12	Sustainable manufacturing; Corporate social responsibility
E-9	Professor	>45	Higher education	>20	CE; Green practices; Sustainability
E-10	Professor	>45	Higher education	>20	CE; Green practices; Sustainability; Sustainable manufacturing
E-11	Manager (CSR)	> 40	Food industry	>15	Corporate social responsibility
E-12	Manager (Supply Chain)	> 45	Construction	>15	Sustainable practices; Corporate social responsibility
E-13	Manager (Corporate Relations)	> 40	Fashion luxury brand	>15	Corporate social responsibility; Sustainable manufacturing

Table 5
Categorisation of barriers.

Category	Code	Barrier
Operational barriers (OPB)	OPB1	Temporal dynamics of technology
	OPB2	Distinct operational and management practices
	OPB3	Monitoring performance within multiple contexts
	OPB4	Risk of information loss
	OPB5	Loss of control over operations
	OPB6	Duplication of responsibility and authority
	OPB7	Lack of transparency and low-quality disclosures
	OPB8	Incompatibility with the corporate "immune system"
Contextual barriers (COB)	COB1	Diverse institutional logics
	COB2	Organisational norms and culture
	COB3	Inbuilt organisational resistance
Perceptual barriers (PEB)	PEB1	Misaligned interests of individuals across sectors
	PEB2	Lack of social movements
	PEB3	Lack of trust among cross-sector collaborators
Strategic and Management barriers (SMB)	SMB1	Internal bureaucracy
	SMB2	Lack of common vision and policy framework
	SMB3	Competition vs. collaboration
	SMB4	Absence of system standardisation for performance management
	SMB5	Risk management approaches
	SMB6	Limited knowledge/experience among decision makers
	SMB7	Absence of commitment by organisations toward sustainability
	SMB8	Poor demand/acceptance for environmentally superior technologies
Governance barriers (GOB)	GOB1	Inflexible policy and structure
	GOB2	Lack of legitimacy
	GOB3	Command–control government regulations
	GOB4	Lack of power asymmetry
	GOB5	Isomorphic institutionalism

sector, construction and luxury fashion respectively. The details of these experts are shown in Table 4.

4.2. Phase 2: Finalisation, categorisation and exploration of Inter-Relationships among barriers using Fuzzy Delphi and Fuzzy DEMATEL

Based on the literature review and through discussion with experts, a threshold value was set at>0.60 to decide on exclusion and inclusion of barriers (Shen et al., 2010; Kumar et al., 2017). Using the Fuzzy Delphi method, the barriers were assessed by the expert responses; all variables were found to be valid and relevant for the study. The steps taken to compute the values of *Sj* have been described in section 3.2. The Fuzzy values with final Sj have been recorded in Appendix Table A2. The values of *Sj* suggest that all variables are valid and must be considered as all values are higher than 0.60. The experts were asked to categorise the barriers. This produced a list of barriers with 5 main categories and 27 sub-categories as shown in Table 5.

Based on the above classification and literature review, a conceptual diagram for the study was developed, as shown in Fig. 2.

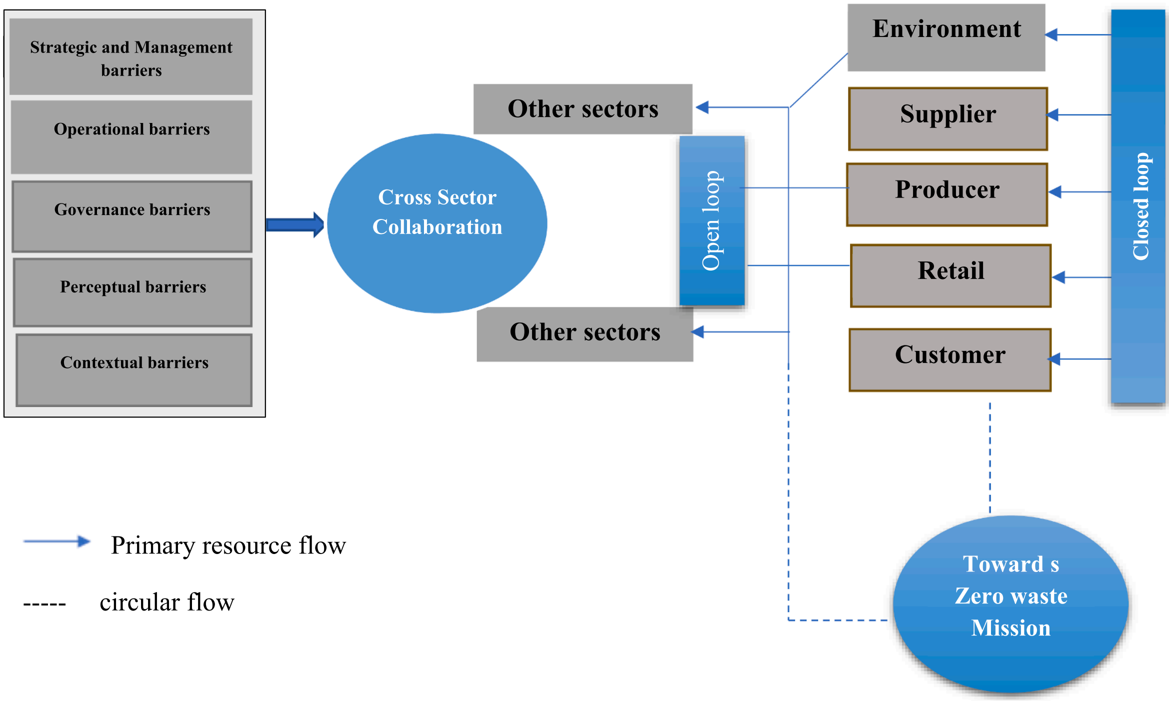

Fig. 2. Conceptual framework for barriers to C-SC for Circular supply Chains ().
Adapted from Farooque et al., 2019b

Table 6
Normalised tables for all three fuzzy values *l, m, u* (Main categories).

Barriers	OPB	COB	PEB	SMB	GOB
(l)					
OPB	0	0.1161	0.0908	0.1584	0.1390
COB	0.1107	0	0.1948	0.2076	0.1754
PEB	0.1714	0.1702	0	0.0496	0.1486
SMB	0.1499	0.1354	0.0077	0	0.1689
GOB	0.2233	0.1341	0.2017	0.1861	0
(m)					
OPB	0.0000	0.1509	0.1356	0.2052	0.1857
COB	0.1536	0.0000	0.2220	0.2368	0.2046
PEB	0.2044	0.2169	0.0000	0.0826	0.1911
SMB	0.1910	0.1821	0.0329	0.0000	0.2119
GOB	0.2485	0.1709	0.2386	0.2308	0.0000
(u)					
OPB	0.0000	0.1509	0.1356	0.2052	0.1857
COB	0.1536	0.0000	0.2220	0.2368	0.2046
PEB	0.2044	0.2169	0.0000	0.0826	0.1911
SMB	0.1910	0.1821	0.0329	0.0000	0.2119
GOB	0.2485	0.1709	0.2386	0.2308	0.0000

Operational Barriers = OPB; Contextual Barriers = COB; Perceptual barriers = POB; Strategic and Management barriers = SMB; Governance barriers = GOB.

The Fuzzy DEMATEL application was used to establish relationships among the five main barriers and their respective sub-categories. All variables were assessed on the linguistic scale mentioned in Table 3 with steps 1 to 4 implemented as discussed in section 3.4. The normalised fuzzy numbers and total relation matrix derived from the step-by-step process for the main categories are shown in Table 6.

Using the formula from eq. (15), a total relation matrix is obtained as shown in Table 7.

The value for the causal diagram is obtained using (D + R) and (D-R) as shown in Table 8.

Based on the (D-R) values, the cause-and-effect relationship is established among the main categories of barriers. The impact results of the five main categories of barriers are shown in Table 9.

The same expert panel was asked to evaluate the sub-categories of barriers to C-SC on a similar linguistic scale. Using Fuzzy

Table 7
Total-Relation matrix T for all three fuzzy values *l, m, u.*

Barriers	OPB	COB	PEB	SMB	GOB
(l)					
OPB	0.176178	0.253923	0.217538	0.304237	0.291804
COB	0.333085	0.199599	0.342343	0.388331	0.373283
PEB	0.337075	0.30934	0.155716	0.233178	0.312378
SMB	0.296755	0.258301	0.147868	0.164834	0.305346
GOB	0.43057	0.328099	0.355143	0.383869	0.23508
(m)					
OPB	0.439652	0.530071	0.47404	0.596836	0.592817
COB	0.649227	0.469808	0.599679	0.688075	0.681659
PEB	0.625769	0.593942	0.380152	0.524404	0.612555
SMB	0.572644	0.525195	0.380151	0.408198	0.584779
GOB	0.750165	0.645763	0.637258	0.715973	0.544886
(u)					
OPB	0.626441	0.73667	0.67243	0.788311	0.791127
COB	0.822361	0.634976	0.738927	0.833764	0.831595
PEB	0.808107	0.789569	0.544964	0.725406	0.805309
SMB	0.773967	0.739162	0.584982	0.587407	0.77335
GOB	0.904817	0.834068	0.795614	0.881506	0.710069

DEMATEL, each cause-and-effect relationship among the sub-barriers was established. The results are shown in Table 10.

To eliminate minor effects, the threshold value (α) is calculated using eq. (17).

$$\alpha = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left[t_{ij}\right]}{N} = 0.0534 \tag{17}$$

The values greater than the threshold value of 0.0534 are included in the total relation matrix based on crisp values. A Network Relationship Map (NRM) was established to present the significance or strength of the relationship between the barriers (main) and sub-barrier (sub-categories); these are shown in the digraph with an arrow (Fig. 3).

By following the same steps, NRMs for the sub-barriers are also developed as shown in Fig. 4.

The elaborated results for each sub-barrier showing the cause-effect relationship are discussed in the next section. Phase 3 includes identification of those strategies to overcome barriers to C-SC for CSCM; this is discussed in Section 6.

4.3. Sensitivity analysis

The results of the model have been validated by sensitivity analysis. To assess the robustness of the model, it is necessary to analyse the model under different conditions (Kumar et al., 2018). In the current study, a sensitivity analysis is conducted by modifying the expert input and then analysing the deviation in results. Based on changes in GOB weights, other barrier weights have been calculated; these are presented in Table 11.

As can be seen in Table 11, GOB has more weight i.e. 0.226. So, we analyse the variation in output by changing GOB weight. Hence, in this instance, GOB weight has been changed from 0.226 to 0.023 (0.226*0.9 = 0.203, 0.226*0.8 = 0.181, 0.226*0.7 = 0.158, 0.226*0.6 = 0.136, 00.226*0.5 = 0.113, 0.226*0.4 = 0.090, 0.226*0.3 = 0.068, 0.226*0.2 = 0.45, and 0.226*0.1 = 0.023). After calculating each barrier weight, all rankings have been calculated as shown in Table 12.

The sensitivity analysis results are shown in Fig. 5.

The sensitivity analysis shows the consistency in ranking of the sub-barriers. The incremental change has not changed any of the results, demonstrating the robustness of the model.

5. Discussion of findings

This study highlights that organisations must understand the emergent need for an integrated framework and practices that support each other's efforts toward circular supply chains; this is aligned with previous research (de Sousa Jabbour et al., 2018). The RBV theory suggests that firms can collaborate to create and sustain competitive advantages through their rare, inimitable and non-substitutable resources. Through joint efforts, waste can be minimized and further reduced toward zero through C-SC. This study assesses the mutual trust and aligned interests from a stakeholder perspective. The study contributes to RBV theory and stakeholder theory by exploring the significance of the shared value of resources and the value chain model as a requirement to developing circular supply chains. The current study has assessed the C-SC barriers in developing CSCM practices and associated inter-relationships. The barriers were finalised using AHC and validated later by the Fuzzy Delphi method. Fuzzy DEMATEL was applied to examine the cause-effect relationships among the barriers to C-SC for CSCM. Table 10 shows the categorisation of cause-and-effect barriers. Perceptual Barriers (PEB), Contextual Barriers (COB) and Governance Barriers (GOB) are grouped into causal barriers whereas Operational Barriers (OPB) together with Strategic and Management Barriers (SMB) are categorised as effect group barriers.

Table 8
Values for the causal diagram.

Barriers	**Di**			**Ri**			**Di + Ri**			**Di-Ri**			**Crisp Di + Ri**	**Crisp Di-Ri**
	l	**m**	**U**	**l**	**m**	**U**	**L**	**m**	**U**	**l**	**m**	**u**		
OPB	1.244	2.633	3.615	1.574	3.037	3.936	2.817	5.671	7.551	−2.692	−0.404	2.041	5.474	*−0.328*
COB	1.637	3.088	3.862	1.349	2.765	3.734	2.986	5.853	7.596	−2.098	0.324	2.512	5.610	0.238
PEB	1.348	2.737	3.673	1.219	2.471	3.337	2.566	5.208	7.010	−1.989	0.266	2.455	5.090	0.214
SMB	1.173	2.471	3.459	1.474	2.933	3.816	2.648	5.404	7.275	−2.643	−0.463	1.984	5.256	*−0.364*
GOB	1.733	3.294	4.126	1.518	3.017	3.911	3.251	6.311	8.038	−2.179	0.277	2.608	5.979	0.212

Table 9
Impact results of main category.

Barriers	*r* + *c*	*r* - *c*	Impact
OPB	5.474	−0.328	*Effect*
COB	5.610	0.238	Cause
PEB	5.090	0.214	Cause
SMB	5.256	−0.364	*Effect*
GOB	5.979	0.212	Cause

Operational Barriers = OPB; Contextual Barriers = COB; Perceptual Barriers = POB; Strategic and Management Barriers = SMB; Governance Barriers = GOB.

Table 10
Impact results of barriers subcategory.

Barriers	Code	*r* + *c*	*r* − *c*	Impact
Operational Barriers (OPB)	OPB1	8.9030	0.2155	Cause
	OPB2	8.5009	0.4522	Cause
	OPB3	8.9380	−0.5487	*Effect*
	OPB4	9.1803	−0.3671	*Effect*
	OPB5	9.3615	0.2633	Cause
	OPB6	8.8094	−0.2133	*Effect*
	OPB7	8.6295	−0.5300	*Effect*
	OPB8	8.5726	−0.0844	*Effect*
Contextual Barriers (COB)	COB1	17.5407	−0.0728	*Effect*
	COB2	18.2172	−0.0828	*Effect*
	COB3	17.6685	0.1561	Cause
Perceptual Barriers (PEB)	PEB1	3.7824	0.1305	Cause
	PEB2	5.0125	−0.1168	*Effect*
	PEB3	5.0571	−0.0573	*Effect*
	SMB1	5.1382	0.2219	Cause
	SMB2	5.2535	0.8044	Cause
Strategic and Management Barriers (SMB)	SMB3	5.5870	−0.4670	*Effect*
	SMB4	5.6853	−0.3731	*Effect*
	SMB5	5.7419	0.3667	Cause
	SMB6	5.3814	−0.0879	*Effect*
	SMB7	5.1576	−0.0803	*Effect*
	SMB8	5.1364	−0.2623	*Effect*
Governance Barriers (GOB)	GOB1	3.5121	−0.0824	*Effect*
	GOB2	3.2143	0.3360	Cause
	GOB3	3.4095	0.1844	Cause
	GOB4	2.8594	−0.1850	*Effect*
	GOB5	3.3332	−0.2706	*Effect*

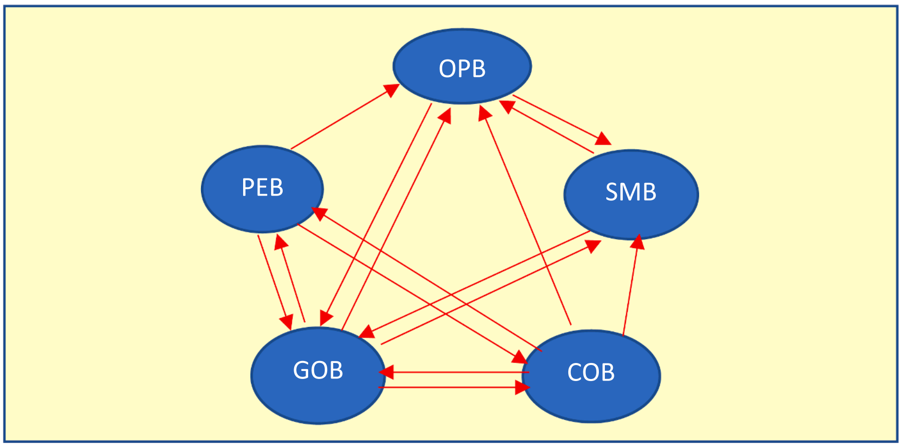

Fig. 3. Network Relationship Map (Main Categories).

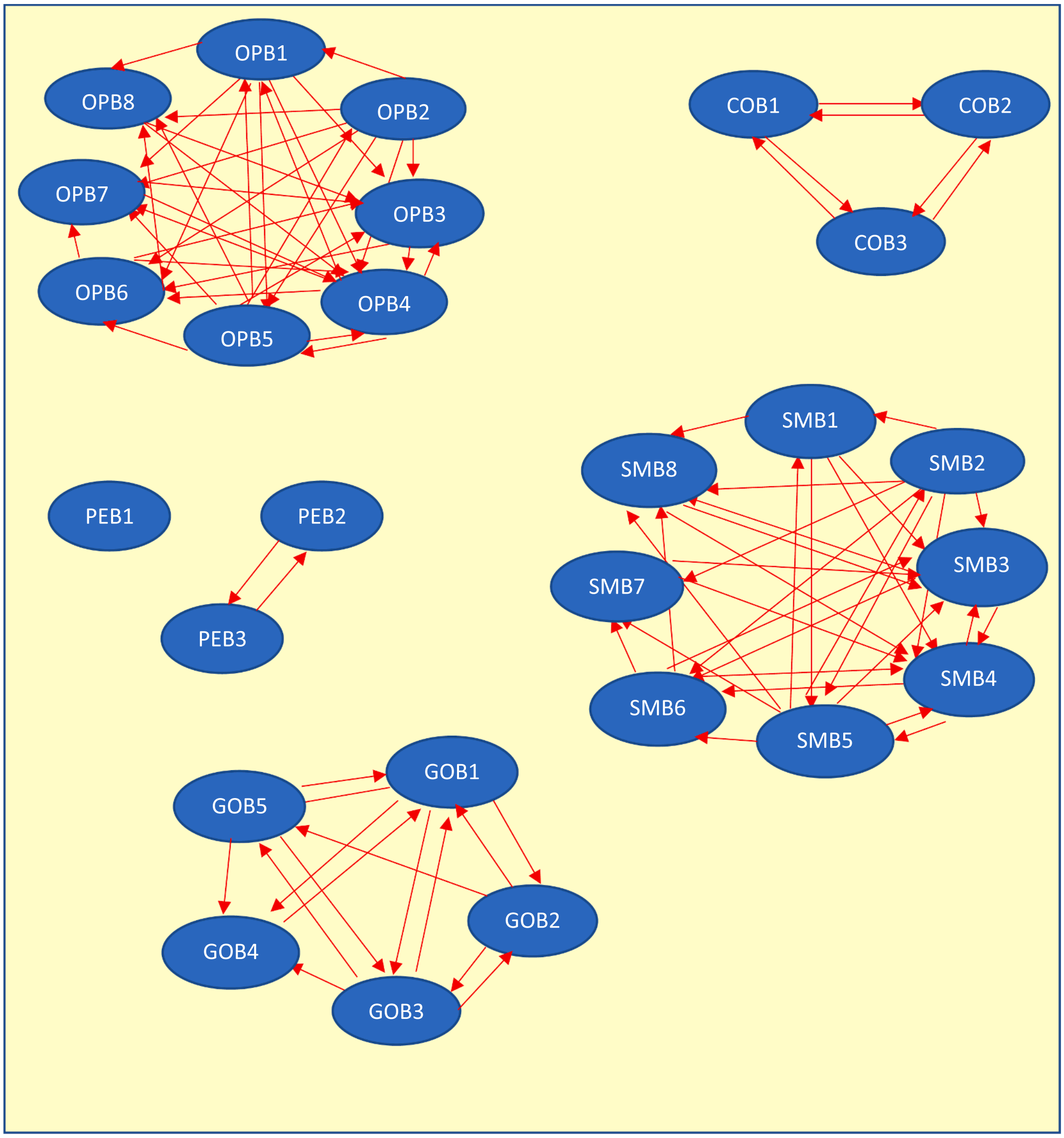

Fig. 4. Network Relationship Map (Sub-Categories).

Table 11
Weights of barriers to C-SC by varying GOB weight.

Barriers	Incremental Changes									
	Normal	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Run 6**	**Run 7**	**Run 8**	**Run 9**
OPB	0.188	0.150	0.154	0.158	0.162	0.167	0.171	0.175	0.179	0.184
COB	0.214	0.170	0.175	0.180	0.185	0.189	0.194	0.199	0.204	0.209
PEB	0.194	0.154	0.159	0.163	0.167	0.172	0.176	0.181	0.185	0.189
SMB	0.179	0.142	0.146	0.150	0.154	0.158	0.163	0.167	0.171	0.175
GOB	**0.226**	**0.203**	**0.181**	**0.158**	**0.136**	**0.113**	**0.090**	**0.068**	**0.045**	**0.023**

5.1. Operational barriers (OPB)

Operational barriers belong to the effect group. The literature in the area of C-SC has shown that the development of C-SC is highly influenced by the presence of operational barriers within an organisation. OPB1, OPB2 and OPB5 are causal group barriers; OPB3, OPB4, OPB6, OPB7 and OPB8 are effect group barriers. The results shown in Table 11 indicate that distinct operational and management practices (OPB2) is the most crucial barrier in the OPB category with the highest (D-R) value i.e. 0.4522. This finding suggests

Table 12
Sensitivity analysis by changing GOB weights from 0.226 to 0.023 through incremental change.

	Normal	Run1	Run2	Run3	Run4	Run5	Run6	Run7	Run8	Run9
OPB1	15	15	15	14	13	10	10	10	10	10
OPB2	16	16	16	15	14	11	11	11	11	11
OPB3	20	20	22	20	19	15	15	15	15	15
OPB4	17	17	17	17	15	12	12	12	12	12
OPB5	12	12	13	11	9	7	7	7	7	7
OPB6	18	18	18	18	16	13	13	13	13	13
OPB7	24	24	25	24	23	20	19	19	19	19
OPB8	19	19	20	19	18	14	14	14	14	14
COB1	4	4	4	4	4	4	4	4	4	4
COB2	1	1	1	1	1	1	1	1	1	1
COB3	2	2	2	2	2	2	2	2	2	2
PEB1	6	6	6	6	6	6	6	6	6	6
PEB2	5	5	5	5	5	5	5	5	5	5
PEB3	3	3	3	3	3	3	3	3	3	3
SMB1	21	21	19	21	20	16	16	16	16	16
SMB2	14	14	14	13	12	9	9	9	9	9
SMB3	25	25	24	25	24	22	20	20	20	20
SMB4	22	22	21	22	21	17	17	17	17	17
SMB5	13	13	12	12	11	8	8	8	8	8
SMB6	23	23	23	23	22	18	18	18	18	18
SMB7	26	26	26	26	25	23	21	21	21	21
SMB8	27	27	27	27	26	25	22	22	22	22
GOB1	9	9	9	9	10	24	25	25	25	25
GOB2	8	8	8	8	8	21	24	24	24	24
GOB3	7	7	7	7	7	19	23	23	23	23
GOB4	11	11	11	16	27	27	27	27	27	27
GOB5	10	10	10	10	17	26	26	26	26	26

that C-SC is required at both micro and macro levels (Kirchherr and Piscicelli, 2019). Cross-sector partners are restricted in their independent planning and management practices that act as a crucial barrier to collaboration. This study highlights organisations need practices to support each other for developing circular supply chains; this aligns with previous research (de Sousa Jabbour et al., 2018). RBV theory suggests that firms can integrate to create and sustain competitive advantages through their individual strengths and resources. This result offers light on the resource utilisation of those firms that operate circular supply chains to their competitive advantage. But currently, due to distinct operational and management practices, C-SC with innovative circular supply chains utilising non-substitutable resources is unachievable. This study also shows that the fear of loss of power has been a constraint to C-SC for CSCM, as suggested by stakeholder theory. This demonstrates the extent of the ability of one sector to impose its will on any potential collaboration.

5.2. *Contextual barriers (COB)*

Contextual barriers belong to the causal group. Belief systems are key to shaping cognition among individuals in an organisation (Bode et al., 2019). Although the need for CE is urgent across the world, due to different contextual barriers, the adoption of CE and CSCM practices is uncommon. COB is the strongest causal barrier based on Fuzzy DEMATEL results. This indicates the strength of resistance among organisations and individuals, limiting them in any collaboration to develop circular supply chains. Contextual barriers include organisational norms and culture that nurture the belief systems of any organisation. The current study shows that internal resistance to adapting to change restricts the organisation's willingness to collaborate or develop a collaborative model. C-SC enabled circular supply chains can only be possible where partners change their current models and collaborate toward a shared goal of zero waste. Previous studies have shown that COB are the most significant barriers that may restrict any organisation to adapt or accept change (Babiak and Thibault, 2009; Bode et al., 2019).

The most widely used framework for understanding organisational culture is from the context of the functionalist. This describes culture as the basic assumptions that help a group learn to cope with its problems of adaptation. The current study shows that due to internal resistance, C-SC may be limited. This barrier is derived from the organisation culture theory proposed by Edgar Schein (1988).

5.3. *Perceptual barriers (PEB)*

Perceptual barriers belong to the causal group. PEB1 is part of the cause group barriers whereas PEB2 and PEB3 are part of the effect group barriers. The results are based on (D-R) values. Among all the sub-barriers, misaligned interests of individuals across sectors (PEB1) is the most crucial perceptual barrier. This finding is aligned with previous research conducted by Loosemore et al. (2020) that suggests individuals from different organisations are limited to their self and organisational interests. Because of pressing global issues, society needs the development of circular supply chains; this requires collaboration among all partners/individuals focused on a common interest in sustainability. Differences in perception or misaligned interests are crucial barriers in CSCM practices. The other

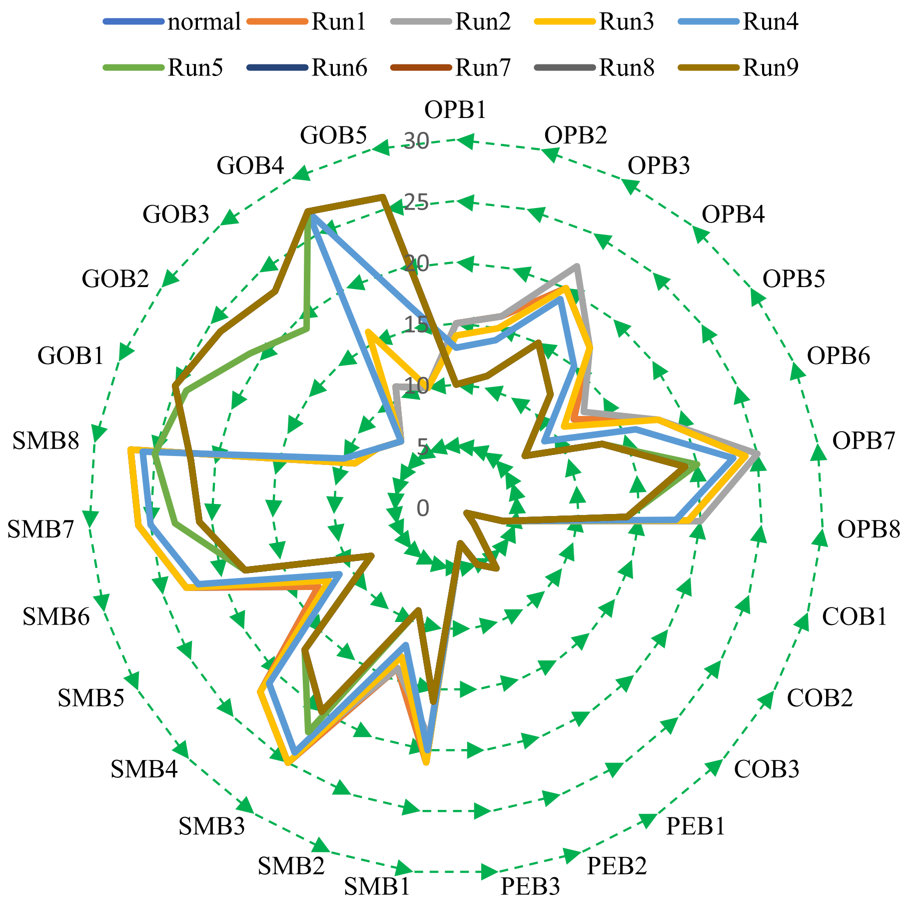

Fig. 5. Sensitivity Analysis.

barrier is the lack of trust among cross-sector collaborators that results in a lack of networking (Klitsie et al., 2018). Trust has always been a critical element in collaborations and can limit the potential outcomes from any partnership (Heuer, 2011; Giusti et al., 2019). This study provides insights on stakeholder collaboration derived from stakeholder theory (Friedman and Miles, 2002). The aligned interests of individuals across sectors and trust among them are the two most critical perceptual barriers among stakeholders. This study assesses the mutual trust and aligned interest from a stakeholder perspective. Stakeholder theory explores the implications of contentious relationships between stakeholders and organisations by introducing compatible/incompatible interests and necessary actions as additional attributes (Friedman and Miles, 2002).

5.4. Strategic and management barriers (SMB)

The primary objective of the C-SC model is to explore those areas that focus on the mutually dependent needs of organisations in terms of management by creating a shift toward shared values that advance the economic conditions in which these organisations may operate (Van de Ven and Sun, 2011). SMB are an organisation's main areas for developing competitive advantage and business models for supply chains (Gunasekaran et al., 2017). C-SC can enhance the capacity, quality, resource optimisation and strategies for a sustainable future through circular supply chains (Babiak and Thibault, 2009). As organisations have their own policies and vision, it is difficult to develop one policy and vision across sectors. C-SC is dependent on the ability of management to create a network consisting of a participative learning environment, involving a region, government and other consortiums. Sometimes, management is reluctant to support activities for sustainable operations. C-SC depends upon strategic and management practices for circular supply chains to have clear and standardised goals. This study shows the importance of having a common vision and policy framework derived from stakeholder theory and RBV (Friedman and Miles, 2002).

5.5. Governance barriers

Governance barriers belong to the causal group and include five sub-barriers. It is the highest influential barrier with a weight of 22.6%. Inflexible policy, lack of legitimacy, command–control government regulations and a lack of power asymmetry are the major issues in implementing C-SC to CSCM. There is a mismatch between the powers of the partner organisations because of different levels

Table 13
Cross-sector strategies to overcome collaboration barriers.

S. No.	Cross-sector strategies	Implied meaning of strategies
S_1	Effective communication to enhance technical know-how	The C-SC performance is driven through effective communication and sharing of technology adoption. It will strengthen collaboration among different sectors to appreciate the technological up-grade requirements for developing circular supply chains (Cao and Zhang, 2010)
S_2	Developing cross-sector leadership and networks	Leaders will play a significant role in transitioning to a circular economy through C-SC. It will also support resource sharing optimally and manage the actions of all collaborators. New Leadership Network should address the needs of each organisation, building trust among diverse stakeholders and engaging other organisations to bring optimal impact. It can also help in achieving economies of scale in the long-term for developing circular supply chains (Brown et al., 2021)
S_3	Unified policy and vision for cross-sectors	Organisations need to develop one common policy and vision across sectors as their operations, models and processes are different (Dutta et al., 2021).
S_4	Data ethics, information and security	As technology, process and information is shared, sectors need to maintain data ethics and information security to develop the association in the long-term (Brown et al., 2021).
S_5	Government policymaking and regulation	Government policies need to be introduced to enhance C-SC for developing circular supply chains as part of their CSR; mandatory measures should be introduced for organisations to follow CE practices and environmental protection initiatives (Dutta et al., 2021).
S_6	Collaborative value capture modelling and co-creating a change-making culture	There is a need for C-SC enabled culture in organisations and co-creation of production through waste as a resource. It includes formal joint decision making to enhance collaborative performance
S_7	Industry 4.0 technologies	I4 technologies can enhance efficiency of operations and can help sectors to optimise and perform their operations through real-time information sharing. It can reduce waste to develop circular supply chains (Dutta et al., 2021).
S_8	Trust and commitment toward circularity and social issues among decision makers	Organisations need to develop trust and commitment among decision makers toward achieving sustainable goals through collaborative efforts for the long-term. Commitment from top-level management for sustainable practices enhances the focus of the organisation to collaborate on CSCM (Konietzko et al., 2020).
S_9	Standardised performance evaluation framework	Performance across sectors needs to be evaluated on standardised measures. It will save costs for all collaborators and enhance transparency; this is essential for achieving circularity (Bai et al., 2020).
S_{10}	Awareness among stakeholders across sectors	The awareness and facilitation of adoption of CSCM practices such as recycling, product return, usage of renewable energy, building a green reputation, raising awareness, developing eco-industrial chains and minimising waste through C-SC need to be enhanced (Hartley et al., 2020)

of resources. Sometimes, the difference in their power delegation in the new collaborative environment acts as a barrier for C-SC for CSCM. The study highlights that their power asymmetry is a barrier to developing C-SC models. It is evident that C-SC can create innovative circular supply chains through their non-substitutable resources (Alkhuzaim et al., 2021) but due to power asymmetry, there is resistance among sectors. This barrier is derived from stakeholder theory (Friedman and Miles, 2002). Those organisations with more power, due to their huge resources, create a level of distrust (Chen et al., 2017). The competition across sectors toward acquisition of scarce resources while seeking credibility and legitimacy can also create tensions (McDonald and Young, 2012; Chen et al., 2019).

6. Strategies roadmap to overcome barriers

Fuzzy DEMATEL has shown the intertwined nature of barriers. Based on the examination of barriers, a list of strategies to mitigate the impact of barriers is shown in Table 13. To find the appropriate strategies, an extensive literature review was conducted and strategies were discussed with experts. From the pool of experts, seven experts were selected, based on their experience and position, for focus group discussion. These experts have sound knowledge of strategies and their impact on the C-SC. Based on their validation, 10 strategies were formulated to overcome the barriers based on the relations explored from the results of the Fuzzy DEMATEL analysis. A focus-group discussion was moderated to enhance the appropriateness of the cross-sector strategies for collaboration. Initially, the Fuzzy DEMATEL findings were presented to the experts, who were then asked to share their opinions to develop a strategic roadmap for enhancing collaboration among the cross-sectors. The experts believed that currently, the Indian economy lacks stringent rules and regulations, lacks a learning culture and has limited Industry 4.0 implementation for developing circular supply chains across sectors. Expert 1 commented "*The organisations do not follow CE practices as no one looks on their linear practices. Lack of government control over the organisation's implementation of CE practices is a major cause for the limited collaboration among the supply ch partners". According to expert 2, "Industry 4.0 enabled supply chains provide real-time data and develop a cyclical flow of information that leads to enhanced C-SC by mitigating communication and transparency barriers". Expert 3 mentioned, "Organisations do possess a range of alternatives that can enhance value and create a culture from which they can learn and develop"*. The other comments made by the experts focus on diverse stakeholders' engagement to enhance efficiency. These strategies will strengthen collaboration by reducing the effect of the barriers.

The experts were asked to respond on a scale of 1 to 10, where 1 represents 'zero impact' on the barrier and 10 represents the 'highest impact'. The experts' responses were accepted and based on the mean score; strategies and barriers were mapped and

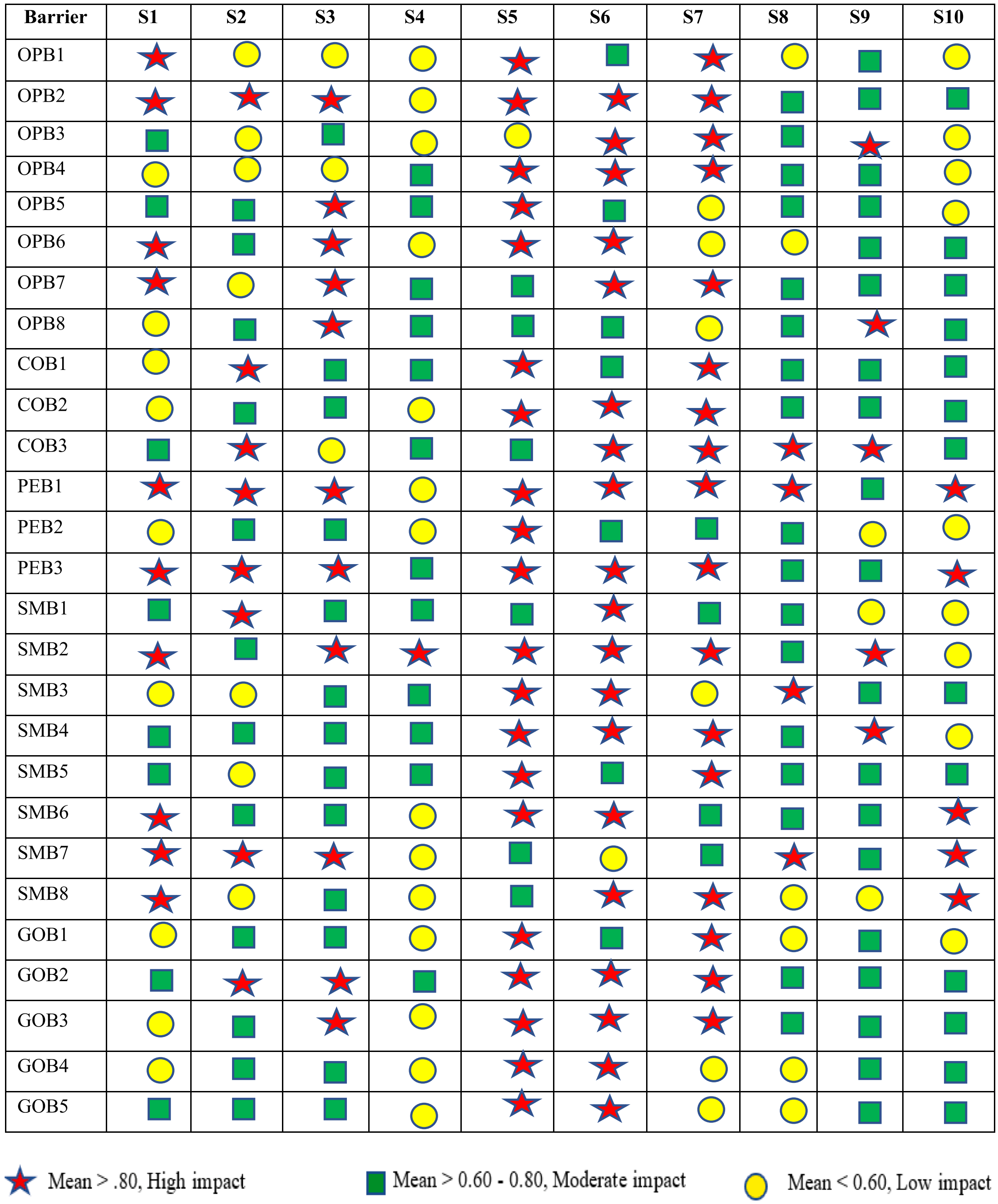

Fig. 6. Strategic mapping.

classified into 3 main categories: High (mean score > 0.80; Moderate (mean score between 0.60 and 0.80) and Low (mean score < 0.60). The mapping of the strategies for each barrier is presented in Fig. 6.

Based on the Fuzzy DEMATEL results, lack of a common vision and policy framework (SMB2), distinct operational and management practices (OPB2) and lack of power asymmetry (GOB2) were the major causal group barriers. The experts thus believe that government policy-making and regulation (S_5), collaborative value capture modelling and co-creating a change-making culture (S_6) plus Industry 4.0 technologies (S_7) will be the most effective strategies to overcome the impact of barriers on C-SC for CSCM. This is shown in Fig. 5.

Collaborative value capture modelling and co-creating a change-making culture will enhance collaboration as this will create a shared value chain in which all collaborators mutually benefit. It will reduce issues of power asymmetry, mistrust and lack of a common vision. This strategy will also develop a change adapting model and facilitate legitimacy toward developing circular supply chains. There is a need for a C-SC enabled culture in organisations and co-creation of production through waste as a resource. This includes formal joint decision making for enhancement of collaborative performance Brown et al. (2021).

Government policy-making and regulation (S_5) strategy is needed in developing nations like India where there is a lack of government intervention. Government policies need to be introduced to ensure a systems approach for C-SC for circular supply chains as part of their CSR (corporate social responsibility). It should be mandatory for organisations to follow CE practices and environmental protection initiatives (Dutta et al., 2021). This will enhance C-SC for the development of future supply chains. Industry 4.0 technologies have high impact on C-SC for CSCM as these provide opportunities for better performance. The strategists and decision makers are recommended to implement advance technologies such as digital twins and digital supply networks to enhance real time sharing and monitoring of their processes. Technology will facilitate transparency and increase trust among collaborators. Previous studies have shown how collaboration is enhanced through intelligent systems. I4 technologies can enhance the efficiency of operations and can help cross-sectors to optimise and efficiently perform their operations through real time information sharing. It can reduce waste on the path to developing circular supply chains.

6.1. Implications of the research

C-SC has been widely promoted by governments and organisations in various countries to develop circular supply chains; however, it is in the nascent phase in India. This study has investigated and validated barriers to C-SC for CSCM practices and has suggested strategic alternatives for mitigating these barriers. The study has also established cause-and-effect relationships to identify inter-relationships among barriers so that an appropriate strategy can be mapped. The findings from this study make both theoretical and practical contributions for managers and policymakers by determining the strength of barriers for C-SC to develop circular supply chains**.** Governments are now considering initiatives for CE and the development of circular supply chains to achieve sustainable outcomes. To achieve this, there is a need to implement C-SC models to enhance the capacity and optimum resource utilisation that can develop circular supply chains. This is only possible through collaborative efforts across sectors to facilitate CSCM practices such as recycling, product return, usage of renewable energy, building a green reputation, raising awareness, developing eco-industrial chains and minimising waste.

6.1.1. Theoretical contributions

This study has made several theoretical contributions to circular supply chains research and the impacts of C-SC. Firstly, it develops C-SC as a new opportunity in developing circular supply chains. The goal of zero waste is desirable and achievable through collaboration among sectors to develop circular supply chains. This study has provided an illustration of how C-SC can help to achieve this. We have identified existing barriers in developing countries such as India, by building a network map to exhibit their inter-relationships. This study contributes to stakeholder theory, highlighting the significance of collaboration among stakeholders and their inter-relationships. Further, it extends the theory to show the successful adoption of circular practices based on stakeholder collaboration and their symbiotic relationships. CSCM depends upon strategic and management practices. Collaboration across sectors can develop a common vision and policy framework derived from stakeholder theory and resource-based theory (Friedman and Miles, 2002) to enable circular supply chains. Secondly, based on stakeholder theory, the success of any organisation depends upon the relationships among stakeholders. The study has shown that there are many barriers to C-SC with contextual barriers being the most significant. For stakeholder collaboration to develop circular supply chains, barriers need to be removed. The general applicability of the framework is demonstrated through a quantitative study using Fuzzy DEMATEL methodology. Thirdly, this study contributes to the establishment of cause-effect relationships among C-SC barriers and sub-barriers. The study is insightful for managers and policy-makers to plan and take strategic actions around government policy-making and regulation, collaborative value capture modelling and co-creating a change-making culture. Industry 4.0 technologies should be considered by decision makers to reduce the impact of barriers on C-SC for CSCM practices in developing countries like India.

The Resource-Based View (RBV) theory proposes that the adoption of circular practices are competencies required to bring innovation to the business model (Jabbour et al., 2019). Circularity is an essential step; barriers that affect collaboration among stakeholders should be examined. This will not only help to reduce the pressures on natural resources, but will enhance collaborative decision making toward sustainable development of the economy. Centred on the resource-based view, resources are scarce and timely utilisation of available resources is crucial as production and consumption are constantly increasing. The identification of resources from the view of organisations helps in managing waste and recycling resources to develop circular supply chains across sectors. From resource dependence theory, the ability to acquire and control scarce resources is the key to survival and success (Murphy and Arenas, 2010). This study contributes by showing how resource optimisation can be achieved through circular supply chains.

6.1.2. Managerial implications

Due to various barriers that have an impact on CE adoption, implementation remains low in the economies of emerging nations. In this context, the implementation of C-SC, particularly for developing CSCM practices, can be enhanced if companies, decision makers and policymakers are aware of the barriers that hamper successful deployment; there needs to be an understanding of the relationships among these barriers. Thus, this study is significant in determining the cause-effect barriers for CE adoption and providing strategic recommendations to reduce the impact of barriers to C-SC for CSCM. This study is useful for managers and decision makers to understand the real issues restricting C-SC; these include lack of a common vision and policy framework, distinct operational and management practices etc. These barriers need to be removed for developing circular supply chains of the future. Some managerial implications are as follows:

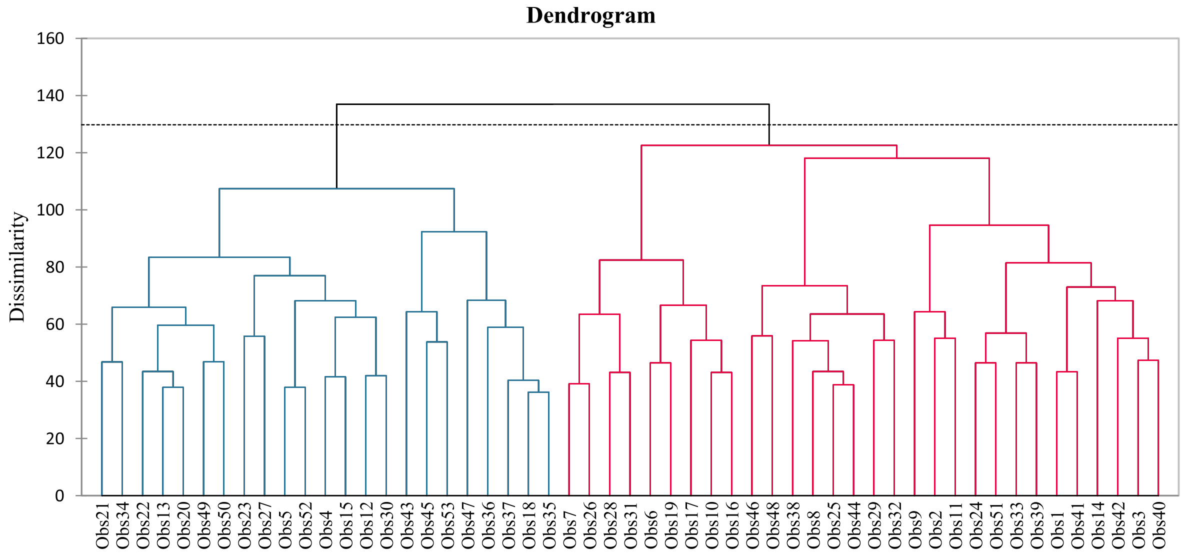

Fig. A1. Dendrogram.

Table A1
Initial list of barriers.

Sr. No.	Barriers		
1	Misaligned interests of individuals across sectors/unenlightened self-interest	28	Stakeholders show hesitation toward collaboration
2	Temporal dynamics of technology	29	Lack of superior technology
3	Lack of trust among cross sector collaborators	30	Distinct interest of stakeholders
4	Diverse institutional logics	31	Different methods toward performance outcomes
5	Lack of integrated planning and management practices	32	Shared vision
6	Monitoring performance within multiple contexts	33	Lack of coordination among multiple contexts
7	Incompatibility with the corporate “immune system”	34	Distinct organisational systems
8	Organisational norms and culture	35	The perception of dominance
9	Internal bureaucracy	36	Hesitation toward information sharing
10	Risk of information loss	37	Lack of synchronisation in control
11	Loss of control over operations	38	Competition toward resource sharing
12	Lack of common vision and policy framework	39	Measuring performance across sectors
13	Competition vs. collaboration	40	Lack of standardisation
14	Absence of system standardisation for performance management	41	Information sharing and Insecurity
15	Inbuilt organisational resistance	42	Resistance to change
16	Poor market for superior technologies	43	Lack of commitment toward sustainable development
17	Lack of adaptive governance structures	44	Lack of stringent governance
18	Lack of legitimacy	45	Lack of legal framework
19	Risk management approaches	46	Fear of risk sharing among sectors
20	Command–control government regulations	47	Lack of appropriate indicators to measure performance
21	Limited knowledge/experience	48	Lack of responsibility of top management
22	Absence of commitment at top-level management	49	Greater importance given to closed loop supply chain logistics
23	Lack of power asymmetry	50	Lack of enthusiasm toward C-SC by stakeholders
24	Low levels of transparency and poor quality of disclosures	51	Inadequate internal and external communication systems
25	Isomorphic institutionalism	52	Fear of losing power
26	Duplication of responsibility and authority	53	Resistance to transition from conventional ways
27	Lack of social movements	54	Economies of scale

Organisations are looking for ways to become circular in nature and transform their supply chains and thus need to develop integrated planning across sectors for a common vision of CSCM adoption and implementation. This may require input from all sectors to form one common shared goal for developing circular supply chains. This study has identified lack of regulation as the main causal barrier and thus for future supply chains, all sectors should base performance toward the common goal of circularity.

- Developing industrial symbiosis networks provides a conducive ecosystem for cross-industry collaborations and synergies in terms of resource sharing and waste elimination. It will enhance resource optimisation through policy making and regulations.
- Circularity in the value chain through C-SC can be achieved. Developing a circular value chain will enhance collaboration across sectors. C-SC enabled culture in an organisation and co-creation of production through waste as a resource will absorb shared culture into the organisation. Managers need to add value at each supply chain step based on industrial symbiosis.

Table A2
Scores for variables undertaken using Fuzzy Delphi.

S. No.	Barriers to C-SC for CSCM	l	m	u	S
1	Misaligned interests of individuals across sectors/Unenlightened self-interest	0.300	0.847	1.00	0.716
2	Temporal dynamics of technology	0.300	0.755	1.00	0.685
3	Lack of trust among cross sector collaborators	0.300	0.817	1.00	0.706
4	Diverse institutional logics	0.300	0.824	1.00	0.708
5	Lack of integrated planning and management practices	0.300	0.833	1.00	0.711
6	Monitoring performance within multiple contexts	0.300	0.781	1.00	0.694
7	Incompatibility with the corporate ‘immune system’	0.100	0.777	1.00	0.626
8	Organisational norms and culture	0.100	0.830	1.00	0.643
9	Internal bureaucracy	0.100	0.742	1.00	0.614
10	Risk of information loss	0.300	0.809	1.00	0.703
11	Loss of control over operations	0.300	0.801	1.00	0.700
12	Lack of common vision and policy framework	0.000	0.865	1.00	0.622
13	Competition vs. collaboration	0.100	0.704	1.00	0.601
14	Absence of system standardisation for performance management	0.300	0.786	1.00	0.695
15	Inbuilt organisational resistance	0.100	0.736	1.00	0.612
16	Poor demand/acceptance of environmentally superior technologies	0.100	0.730	1.00	0.610
17	Lack of adaptive governance structures	0.100	0.829	1.00	0.643
18	Lack of legitimacy	0.100	0.717	1.00	0.606
19	Risk management approaches	0.100	0.761	1.00	0.620
20	Command–control government regulations	0.100	0.710	1.00	0.603
21	Limited knowledge/experience	0.500	0.916	1.00	0.805
22	Absence of commitment of top-level management	0.000	0.842	1.00	0.614
23	Lack of power asymmetry	0.100	0.721	1.00	0.607
24	Low levels of transparency and poor quality of disclosures	0.100	0.833	1.00	0.644
25	Isomorphic institutionalism	0.100	0.715	1.00	0.605
26	Duplication of responsibility and authority	0.100	0.727	1.00	0.609
27	Lack of social movements	0.100	0.798	1.00	0.633

- C-SC may be an effective way to fight uncertainty and provide strong circular supply chain as each sector is using each other’s by-products. The inclusion of industry 4.0 can be an efficient strategic alternative to enhance transparency, agility and real time information sharing; collaboration across sectors must be encouraged to develop future circular supply chains.
- Commitment from top-level management to sustainable practices will enhance the focus of an organisation to collaborate on CSCM. C-SC will develop knowledge and preparedness toward CE adoption and implementation.

7. Conclusions

C-SC is an emerging area that can be researched to explore inter-dependencies, synthesise critical functions, resources, information and capabilities. With support from government and private organisations, more initiatives can be introduced to resolve ongoing crucial societal issues. This study has focused on barriers to C-SC for developing future supply chains with a zero-waste mission. In the current dynamic environment, each organisation has to deal with these barriers to enable the development of C-SC enabled circular supply chains. From this perspective, the current study differentiates from previous literature that has focused on C-SC and CSCM separately. Three research questions are asked “What barriers restrict C-SC for CSCM in India?”, “What are the inter-relationships among these barriers to C-SC existing in India?”, and “What are the strategic alternatives to reduce the impacts of the barriers to C-SC for effective CSCM practices?”

To answer the first research question, 27 barriers to C-SC for CSM have been explored through a literature review; further validation was made by inputs from experts in the field. For the second research question, Fuzzy DEMATEL was applied to uncover the inter-relationships among these barriers. For the third research question, a strategic roadmap was developed based on the strategic alternatives mapped with each barrier. The result of the study shows that governance barriers (GOB) and contextual barriers (COB) are the most crucial barriers that restrict organisations to collaborate across sectors and develop circular . The study has identified the cause-and-effect group barriers that are essential for consideration by policy makers. The relevance and causal nature of contextual, perceptual and governance barriers, as well as the impact of effect group barriers, including operational and strategic plus management barriers, are shown in the study.

Furthermore, strategies, such as government policy-making and regulation (S5), are needed in developing nations like India where there is a lack of government intervention. Social issues are complex and impossible for one organisation alone to tackle; thus, multi-faceted, multi-sectorial and multi approaches are needed for any resolution. C-SC can encourage long term relationships with high levels of interdependency, risk sharing, common goals and collaboration for mutual benefit. Managers would benefit by exploring the strength of C-SC; this can enhance the efficiency of their systems and improve optimal decision making.

This study offers insights for organisations and all their supply chain partners, irrespective of direct or indirect involvement. India is still at a nascent stage due to the lack of facilitating support and policies (Dutta et al., 2021). Also, it has high resource extraction compared to other nations. The transition to circular supply chains is dependent on the collaborative model of resource sharing across sectors. GOB is the most influencing causal barrier in C-SC (weight 0.226) as shown in Table 11. This shows that there is need of stringent governance for C-SC to enhance the transition to CE in India. Currently, the Government of India (GoI) has initiated various circularity programmes intended to lead to sustainable development. However, these policies are fragmented, focusing on individual themes and lacking a systematic approach. While aspects of CE principles can be found in fragmented regulations, a clear and systematic approach is needed, including integrating CE concepts into existing government initiatives.

These findings raise serious implications for policy makers in addressing governance and environmental issues. The foremost contribution of this study is conceptualising C-SC in the context of integrating CE philosophy in SCM, a new frontier in supply chain sustainability research and practice. The second significant contribution is developing a theoretical framework drawing on multiple organisational theories to identify barriers to C-SC for CSCM. Thirdly, to the best of our knowledge, this is the first attempt to systematically investigate and prioritise the barriers to C-SC. The results suggest lack of government regulations and enforcement as the key cause barriers. Moreover, lack of collaboration/support among SC partners also restricts C-SC.

This study has some limitations that need to be highlighted for future studies to consider. The identification and finalisation of barriers was very challenging. The dynamic environment and technological advancements will pose more barriers for organisations in future. The study has investigated the barriers to C-SC for developing circular supply chains but the capacity to transition depends on internal capabilities; this has not been considered. Thus, future studies can assess the internal capabilities of organisations and their impact on CSCM. Also, the data has been taken from only one country; however, the study can be replicated in other developing countries where CE transition is at the initial phase. Previous literature has shown that an organisation's size is a consideration and thus moderating effects can be measured in future studies. Finally, the cause-and-effect group developed in the current study needs to be investigated further. Future research may develop quantitative approaches to complement the qualitative perspectives of the proposed framework to expand the scope of the study.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

None.

Appendix. -A

See Fig. A1, Table.A1, Table A2

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