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ORIGINAL RESEARCH

Barriers to product return in a circular supply chain: a case from a retailing industry

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Abstract
The circular supply chain (CSC) plays a pivotal role in delivering sustainable products to end users, profoundly affecting organizational performance and societal welfare. In this ecosystem, effective Product Return Management (PRM) is crucial, as consumers play a pivotal role in returning used products for reuse or recycling. Despite its significance in waste reduction and attaining environmental and economic goals, scant research has explored product return barriers within CSC. This study bridges this gap by investigating and prioritising these barriers to enhance the circular economy. Employing a systematic literature review (SLR), we extracted and screened 13 product return barriers in CSC using the Grey Delphi method. Subsequently, we introduced an enhanced version of the Group Grey-Best–Worst Method (GG-BWM), a novel approach that harmonises expert judgments by addressing uncertainties through Grey Theory and incorporating both individual-level and group-level inconsistency ratios. The findings highlight lack of motivation, lack of consumer awareness, and lack of proper infrastructure as the most critical barriers. Furthermore, sensitivity analysis conducted across 11 scenarios emphasises the significance of our results. This study contributes to the group multiple criteria decision making (MCDM) methods and CSC literature, while offering actionable insights practitioners seeking to improve the effectiveness of their CSC strategies.

Keywords Circular supply chain · Product return management · Group grey best worst method (GG-BWM) · Group multiple criteria decision making (MCDM) methods

1 Introduction

Circular supply chain (CSC) is a new philosophy in supply chain management that provides economic, social, and environmental benefits to all stakeholders by recovering resources in

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a circular cycle (Kabadurmus et al., 2022). Used products can be processed based on circularity principles by the original supply chain to extend the life cycle of the products. This concept can go further by recovering value from wastes through collaboration with other organizations within the same or different industrial sectors. The first archetype is called the closed loop supply chain, while the latter is called a CSC (Farooque et al., 2019). Under circular economy context, multiple organizations collaborate and make maximum use of recovered resources. For example, the remaining materials in the recovery of Organization A are sent to Organization B, and Organization B uses these materials as raw materials in its production line (Gunasekara et al., 2023). CSCs, through recycling and remanufacturing, provide an opportunity to address resource depletion (Agrawal et al., 2023a, b). CSC positions organizations within a global framework to maximize the value of their products while considering economic, social, and environmental concerns simultaneously. CSC can also inform stakeholders of the organization's long-term goals and risks (Romagnoli et al., 2023). Product design improvement (Lahane et al., 2023), product cycle extension (Kumar et al., 2023), energy and routing optimization (Faisal, 2023), vehicle utilization maximization (Detwal et al., 2023), and the development of warehousing and packaging solutions (Abideen et al., 2021) are additional outcomes of CSC.

Disposal behavior of consumers have been extensively investigated in the literature (Phulwani et al., 2021). According to Phulwani et al. (2021), there are five disposal options for consumers: (1) direct discarding, (2) storing, (3) reselling, (4) giving away, and (5) returning. Supply chain managers have key role in facilitating responsible consumption by consumers (Gupta & Agrawal, 2018). While there are various types of responsible disposal behavior, this study focuses on the "returning" aspect. According to Gupta and Agrawal (2018), responsible consumption involves "any consumption-related behavior that reduces the negative impact of consumption on the environment". In CSCs, supply chain managers are striving to find innovative methods of product collection, motivating consumers to return the used products, and consequently enhancing the circularity performance of their companies (Amir et al., 2023). Product return management (PRM) which is part of a CSC, is a key process that begins with the final users who can receive some kind of benefits after consuming the original product by returning it to the source (Ambilkar et al., 2022). Product cycle extension is another benefit of PRM and can lead to other benefits such as improving the performance of Customer Relationship Management (CRM), increasing demand, and creating effective channels for product distribution and collection if managed correctly (Zhang et al., 2021).

The significance of PRM in CSCs is evident, yet limited research investigated enablers and barriers to successful PRM. While previous studies have extensively addressed the factors influencing product return by consumers, to our knowledge, there is a gap in research on studying the barriers to product return by consumers employing MCDM methods. For instance, Testa et al. (2020) explored the influence of personal concern, pro-environmental behaviors, greenwashing beliefs, consumer innovativeness, and personal predisposition to seeking information on the purchasing of circular packaging drawing insights from a sample of Italian families. Gong et al. (2020) identified collaboration as a pivotal enabler, while highlighting inadequate recycling infrastructure as the primary barrier in fostering circularity within the UK's Fast-Moving Consumer Goods (FMCG) industries. Moreover, an extensive literature review by Phulwani et al. (2021) disclosed the disposal behaviors by consumers and the most important influencing factors on that based on the theory of planned behavior (Ajzen, 1991) and the value-belief-norm theory. Vidal-Ayuso et al. (2023) conducted an extensive literature review on the role of consumer behavior in circular economy and concluded with some insightful research recommendations. Notably, this study aligns with

one of their recommendations, particularly focusing on analysing consumers' post-purchase behavior.

Literature review revealed that previous studies have extensively addressed the factors influencing circular behavior of the consumers; however, there are two gaps in research on studying the barriers to product return by consumers. Firstly, there is scant research that empirically delves into the barriers to product return in a CSC. Understanding these barriers holds considerable significance because unresolved barriers to product returns may hinder supply chains efficiency and effectiveness in terms of circularity, and it will reduce their total productivity, as well. In addition, failure to identify the barriers of PRM leads to failure to achieve economic, social, and environmental goals and reduces sustainability in CSC hindering progress towards industry-wide Sustainable Development Goals (SDGs), notably, SDG 12—responsible consumption and production. Secondly, to better understand these barriers and offer more actionable managerial insights, it is important to rank and prioritize them, especially given that management often faces resource constraints. The application of MCDM methods could be highly beneficial in this context, yet these methods have not been widely utilized in the field of PRM. Therefore, this research represents one of the first attempts to apply MCDM methods to analyze the barriers to product returns within a CSC. This contribution also introduces two key innovations at its core that are explained below.

In decision-making processes, two key stages are typically involved: (1) weighting the criteria and (2) evaluating the alternatives based on these criteria. Weighting methods are widely used to prioritise a set of factors or elements. For instance, Khan et al. (2023) utilised the Best Worst Method (BWM) to prioritise barriers to blockchain implementation in food supply chains. Among the various weighting methods, the Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Entropy, and BWM are particularly prominent in the literature. In this study, we present two key methodological contributions. First, we developed a novel variant of the Best–Worst Method (BWM) based on the Group Grey-Best–Worst Method (GG-BWM) introduced by Petrudi et al. (2021), incorporating new group inconsistency measures. Our enhanced GG-BWM offers a more efficient solution compared to both the traditional BWM and the approach proposed by Petrudi et al. (2021), while also introducing improved inconsistency measures for group decision-making. Second, to the best of our knowledge, this is the first application of an MCDM method—specifically, this GG-BWM variant—to investigate the barriers to product returns in a Circular Supply Chain (CSC).

Hence, to bridge these research gaps, this study aims to first identify the barriers to PRM within CSC. To achieve this, PRM barriers are first extracted through a SLR. Subsequently, these barriers are subject to scrutiny using the Grey Delphi method, incorporating insights from experts within a retailing industry. Finally, a novel version of the GG-BWM is utilised to rank these barriers. BWM is one of the new MCDM methods that provide reliable results by reducing pairwise comparisons compared to other traditional weighting methods like AHP (Rezaei, 2016). Notably, this paper introduces a novel enhancement to the GG-BWM model by introducing two types of inconsistency ratios: individual-level inconsistency ratio and group-level inconsistency ratio. While the former is prevalent in existing literature, the latter constitutes our primary contribution to the GG-BWM model. Through this method, the relative importance of each PRM barrier in CSC is obtained. By knowing the importance of product return barriers, supply chain managers can have a better understanding of these barriers and prioritize them in their strategic decisions and find effective solutions to overcome them.

The paper is structured as follows. Following this introduction, in Sect. 2, the literature review is discussed and the barriers to product return in CSC are introduced. Section 3 describes the Grey Delphi method and the enhanced GG-BWM. The results are presented in

Sect. 4. In Sect. 5, the results are discussed and compared with the previous studies. Finally, in Sect. 6, the paper concluded with the conclusions and the future research direction.

2 Literature review

2.1 Supply chain

Early in the 1980s, a book from the consulting firm Booz Allen and Hamilton used the term "supply chain management" for the first time which was used to refer to the flow of materials in manufacturers (Harland, 2024). Although similar concepts have been used since the 1960s, such as materials management, commercial chain, value chain system (Porter, 1985), etc., they provide different perspectives. However, the first conceptualization of supply chain management took place in 1980s, which meant "the integration of the management and flow of materials in manufacturing organizations, from buying and selling with suppliers, through production, to sales, distribution, and customer service to customers" (Stevens, 1989). Then, the term supply chain appeared in academic publications in the early 1990s and became a common term in organizations and academia.

Over time, new approaches to supply chain evolved. Leanness is one supply chain strategy that aims to produce and deliver products as quickly as possible with the least waste (Niknejshan et al., 2024). Agile supply chain refers to responsiveness, competence, flexibility, and speed in supply chain management (Christopher, 2000; Mishra et al., 2024). Resilience supply chain requires companies to react appropriately to risks and unforeseen events (Rashid et al., 2024). Greenness and sustainability in supply chains has become more crucial than ever to responding external pressures from governments, customers and other stakeholders. The integration of Lean, Agile, Resilient, and Green strategies led to the evolution of LARG supply chain (Khanzadi et al., 2024). In recent decade, CSC has also attracted the attention of academics and organizations.

2.2 Circular supply chain

The emergence of the circular economy in recent decades and its integration into supply chain management has led to the creation of a CSC (Gunasekara et al., 2023). The difference between CSC and a linear supply chain is in creating and maintaining product value, and CSC performance is also affected by product value (Amir et al., 2023). CSC through open and closed loop systems causes the configuration and coordination of production processes in the organization and connects them to business units, internal and external organizations (Ciccullo et al., 2023). Since the CSC focuses on economic, social, and environmental goals, it increases the participation of stakeholders and stakeholders in the production processes, and with the strategies it brings, it promotes sustainability in organizations and identifies the compatible and incompatible interests of the organization, as well (Vegter et al., 2023).

CSC forms a system in the organization that causes the products to be restored and recycled after consumption and used again. In this way, waste in organizations is minimised, and the organization achieves sustainability (Kotabe, 2023). Today, organizations make large investments to move their organization toward sustainability and refurbish and recycle their products (Ciccullo et al., 2023). One area that contributes to the objectives of the CSC and leads to the recovery and recycling of products is Product Return Management (PRM).

2.3 Product return management

PRM is a process that begins with the return of used products by consumers and continues with the collection and organization of products. Then it ends with the recycling and refurbishing of products by organizations (Ambilkar et al., 2022). Returning the product has a great influence on the final price of the producers, the behavior of the consumers, and their attraction, and it encourages the consumers to buy. Through product returns, useful information can be obtained from consumers and in this way, marketing, design, and product quality can also be increased (Sahoo et al., 2018). Various factors such as product information sharing (Lysenko-Ryba & Zimon, 2021), customer perception (Das & Dutta, 2022), product recyclability (Dzyabura et al., 2018), and product packaging (A. Mishra et al., 2023) affect PRM.

As CSCs evolve to meet consumer expectations and market demands, it can be expected that PRM plays an important role in CSC (Lysenko-Ryba & Zimon, 2021). Drawing on the literature and expert opinions, PRM contributes significantly to enhancing the effectiveness and efficiency of CSC processes. Since the product return process begins with consumers, they serve as the pivotal starting point of the PRM process (Bernon et al., 2013). In this process, consumers return a product to the point of purchase to exchange or receive a reward. At this stage, activities are carried out to return the product to the main chain for final disposal or recycling (Abdulla et al., 2019). One of the barriers in this process is the lack of motivation of consumers to participate in PRM projects (Duong et al., 2022). Without consumer participation, the PRM process cannot be completed, and the sustainability objectives of the CSC remain unachievable. Based on the theory of psychological behavior, reward is a lever that can strengthen customers' decision to return the used product (Kimmel, 2018). According to operant conditioning, providing a reward leads to the maintenance of desired behavior and conditions it. For instance, organizations can set the condition of free shipping on subsequent purchases in exchange for receiving a used product and consider it as a reward and a kind of service for customers. In this way, customers' motivation can be increased, as well. Psychological research of consumers shows that the presence of a motivation factor in customers causes them to return used products (Gelbrich et al., 2017). Furthermore, to improve the level of customer satisfaction towards products and services, the psychological behavior of consumers should be considered at every level of the CSC (Liu et al., 2019).

Although external reward is crucial in facilitating product return processes, other factors also shape the consumer behavior. For instance, according to the theory of planned behavior (Ajzen, 1991), subjective norms and perceived behavioral control play key roles alongside motivation. Actual behavioral control refers to the extent to which individuals believe they have the necessary resources to perform a specific behavior. In the context of product returns within circular supply chains, companies must provide adequate facilities and infrastructure to instil confidence and ensure ease for consumers returning used products. Subjective norms, however, are more challenging for companies to manipulate. These norms refer to the social pressures that consumers perceive to perform or refrain from a behavior. According to Melnyk et al. (2022), marketers should focus on highlighting societal benefits rather than relying solely on sanctions or rewards to reduce consumer resistance and increase acceptance. Altogether, by addressing various aspects of consumer behavior in this way, companies can enhance participation and contribute to the sustainability objectives of CSCs.

2.4 Retail industry

The retail industry is one of the important links of the supply chain, which is the intermediary between the producer and the final consumer who provides the product or service to the customers (Endo, 2014). Since supply chain networks are not complete without the retail industry, it plays an important role for organizations. In fact, without the retail industry, the organization faces serious challenges in earning profit and customer satisfaction. This industry has made it easy for consumers to receive their goods and enjoy useful advantages such as availability, faster delivery, and discounts (Anggara et al., 2023).

Retail is designed to follow the strategic goals and vision of organizations and increase customer satisfaction through optimal service. Through retailing, organizations can identify opportunities and adopt appropriate strategies for the target market (Volpato & Stocchetti, 2008). Retail sales influence consumer behavior and meet their expectations. Many retailers are categorized based on the type of merchandise carried. Some retailers offer products that have a short shelf life, such as cosmetics, stationery, shoes, and clothing (Dixon, 2007). Some other foods supply household items such as detergents, cleaners, etc., which operate mostly in hypermarkets, convenience stores, or a combination of them (Beitzen-Heineke et al., 2017). There are also retailers that offer heavy goods such as automobiles, home appliances, furniture, etc. (Hameli, 2018).

The retail industry has become a big business with a lot of turnovers, recently. World retail giants such as Walmart, Amazon, and Costco had a total revenue of more than 900 billion dollars by 2020 (Bamidele-sadiq, 2022). In the private sector of the United States, the retail industry is considered one of the largest industries with employing 52 million people (Gibbon, 2023). Also, Europe's largest retail store is located in Germany and belongs to Schwarz-Gruppe, which has a turnover of more than 140 million euros until 2022 (van Huellen and Ferrando, 2023). Meanwhile, in emerging economies, the retail industry is growing and have become a key driver in economic and social growth.

In emerging economies such as the UAE (Arthur et al., 2020), Qatar (Mehrez, 2019), India (Rauf et al., 2023), and Iran (Abbasi et al., 2021), the retail industry plays an important role in the economy of these countries. The retail industry is considered as one of the key indicators in Iran's economy (Mohammadi, 2015). The retail industry has become the largest non-agricultural occupation in India (Sarkar & Kundu, 2019). According to Ben Hassen et al., (2020), the government of Qatar has strongly developed the retail industry to meet the demand for personal consumption in its landscape. In addition, The retail industry contributes $2.5 million to the UAE economy (Elmelegy et al., 2017). Since retailers are in direct contact with the customers, we focused on this industry to explore the product return barriers from their points of view.

2.5 Barriers to product return in CSCs

To identify the barriers to PRM in CSC, a SLR was conducted in the literature on PRM and CSC. Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA) was used to review the literature. PRISMA is a widely used framework for conducting literature reviews and is commonly employed in logistics and supply chain management research (Ahmed et al., 2024; Cordeiro et al., 2021). According to the Moher et al. (2010), PRISMA is conducted in four stages: Identify, Screen, Eligibility, and Include. One feature of the PRISMA is that it has clear and concise steps and leads to more reliable results.

In the first step, the keywords PRM and CSC were searched in Scopus and Web of Science databases. This search was conducted between 2017 and 2023, and titles, abstracts, and keywords were examined in Scopus and Web of Science. The search in this Scopus and Web of Science was formulated as follows:

"TITLE-ABS-KEY(("Circular Supply Chain" AND " Product Return Management" AND "Barriers") AND (DOCTYPE(are) AND NOT DOCTYPE(bk) AND NOT DOCTYPE(cp) AND NOT DOCTYPE(ed)) AND (LANG(English)) AND (PUBYEAR AFT 2017 AND PUBYEAR BEF 2023)".

In the second stage, three criteria of (1) journal papers, (2) English papers, and (3) authentic journals were considered while screening the articles, and non-academic sources such as book chapters, conference papers, and special letters were excluded to obtain more accurate results. In the eligibility stage, non-English papers and duplicate data were removed. In the final stage, the application of filters resulted in 23 papers being obtained. Final papers were analyzed in Microsoft Excel 2019 software and are summarised in a table in this study.

The literature review shows that research in PRM and CSC is growing. Karlsson et al. (2023) investigated product return management strategies in organizations. Dzyabura et al. (2023) examined PRM in retail sales. Sandberg (2023) studied CSC in leading industries. The contribution, methodology (i.e., quantitative or qualitative), and area of study (i.e., CSC or PRM) of the SLR are briefly shown in Table 1.

Although researchers have investigated PRM and CSC, to our knowledge, scant research has specifically conducted on the barriers to product return in CSC. Furthermore, to our knowledge, no prior study has classified and ranked these barriers using multi-criteria decision-making (MCDM) methods. To address this gap, the present study investigates the barriers to product returns in CSC and introduces a novel MCDM approach to prioritize and highlight the significance of these factors. Based on the literature, 13 key barriers were identified that deter consumers from returning used products. These barriers along with their definitions are shown in Table 2.

3 Methodology

The objectives of this study include: (i) proposing a list of barriers pertinent to product return within a CSC through a SLR, (ii) introducing an innovative methodology integrating Grey Delphi and an enhanced GG-BWM to prioritise these barriers, and empirically validating the proposed framework via a case study from retailing industry, and (iii) offering actionable insights for supply chain managers to effectively navigate these barriers within the retailing industry context. To achieve this aim, a combined SLR, Grey Delphi, and an enhanced GG-BWM approach was applied in this study. The framework of this study is shown in Fig. 1.

An initial list of barriers to PRM in CSC was derived through a SLR employing the PRISMA framework, a widely favoured approach among researchers (Li et al., 2023). The search was conducted through PRISMA in the Web of Science and Scopus databases spanning the years 2017–2023. Initially, 64 articles were found, and by applying filters such as non-English language papers, duplicate papers and irrelevant papers, 23 papers were finalised. Through meticulous analysis of these finalised articles, a synthesis yielded 13 discernible barriers to PRM in CSC, forming the basis for the subsequent phase of investigation.

To analyze the initial list of barriers to product return, we consulted industry experts whose characteristics are summarised in Table 3. As noted by Amoozad Mahdiraji et al.,

Table 1 Overview of the relevant studies

References	Contribution	Methodology		Area of study	
		Qualitative	Quantitative	CSC	PRM
Karlsson et al. (2023)	Examining the key components of PRM in management strategies	Case study approach			*
Agrawal et al., (2023a, 2023b)	Using the residual value of products in CSC by a re-commerce company	LR	Game theory	*	
Mishra et al. (2023)	Investigation of product service systems in CSC	SLR-Bibliometrics		*	
Dzyabura et al. (2023)	Investigating methods of predicting product return rates in retail	LR			*
Kumar et al. (2023)	Examining the success factors of the integration of Industry 4.0 and CSC	LR	F-DEMATEL	*	
Ciccullo et al. (2023)	Investigating the mechanisms and capabilities of CSC in industries	EMS		*	
Sandberg (2023)	Examining the capacities of circular supply chain orchestration in leading industry	SLR		*	
Das and Dutta (2022)	Investigating consumer behavior in product recycling	LR			*

Table 1 (continued)

References	Contribution	Methodology		Area of study	
		Qualitative	Quantitative	CSC	PRM
Duong et al. (2022)	Systematic review of PRM research field and presentation of the framework	SLR-bibliometric			*
Ambilkar et al. (2022)	SLR in the field of PRM	SLR			*
Lysenko-Ryba and Zimon (2021)	Examining the experience of customers in product returns and how to share product information		Fisher's exact test		*
Zhang et al. (2021)	Minimizing waste in CSC	SLR		*	
Xue et al. (2021)	Investigating the repurchase intention of B2B customers	LR	SEM		*
Lesmono et al. (2020)	Investigating the effects of cost change on PRM and consumer behavior	LR			*
Wan et al. (2020)	Presentation of PRM strategy model	LR			*
Kalpoe (2020)	The role of smart technologies in PRM	LR	Bayesian-BWM		*

(2023a, 2023b), purposive sampling is a widely accepted approach in multi-criteria decision-making (MCDM) studies, allowing experts to be selected based on predefined criteria. In this study, several criteria were considered when inviting participants to ensure the relevance and reliability of the findings. Specifically, the selected experts were motivated by the potential benefits of our newly developed method for prioritising barriers to product returns. Each expert had at least 10 years of experience in the retail industry. We extended invitations to 28 experts from a prominent Iranian retail company located in Mazandaran Province. For confidentiality reasons, the company's name is not disclosed. This company operates over 190

Table 1 (continued)

References	Contribution	Methodology		Area of study	
		Qualitative	Quantitative	CSC	PRM
De Borba et al. (2020)	Identifying barriers to PRM inefficiency	SLR			*
Frei et al. (2020)	Examining sustainable practices in PRM	LR			*
Farooque et al. (2019)	SLR in the field of CSC	SLR		*	
Pei and Paswan (2018)	Investigating customer behavior in online product returns	LR			*
Shaharudin et al. (2017)	Investigating the product return rate in the supply chain of manufacturing companies		SEM		*
Kianpour et al. (2017)	Investigating the influencing factors of customers' attitude in product return participation		PLS-SEM		*
Zailani et al. (2017)	Investigating the barriers of PRM in the automotive industry	LR	PLS		*

LR Literature review, *F-DEMATEL* Fuzzy- Decision making trial and evaluation laboratory, *EMS* Exploratory multiple case study, *SEM* Structural equation modelling, *PLS*: Partial least squares

branches across the province. To recruit participants, we contacted the company's two head offices and requested that administrators distribute our invitation letter to senior managers. Ultimately, five of the 28 invited experts agreed to join the panel.

The experts were provided with a detailed overview of the research objectives, the list of barriers, and the advantages of the proposed method. Prior to data collection, the questionnaire underwent a thorough preprocessing stage to ensure clarity, relevance, and consistency of the items. This process included: (1) Reviewing the questionnaire by four academics with expertise in circular supply chains and decision-making methods to refine the phrasing of the barriers for improved validity; (2) Pilot testing the questionnaire with two non-participating

Table 2 List of product return barriers

PRM barriers	Brief definition	References
Lack of proper infrastructure	The lack of technology infrastructure and innovational knowledge causes PRM has not enough performance and proper recovery in CSC has no efficiency. In this way, economic, social, and environmental goals are not achieved	Mishra et al. (2023) and Zailani et al. (2017)
Lack of expert staff	The expert staff in CSC and PRM leads to the development of the organization and improves communication with the customer, and sustainability goals are also achieved	Gunasekara et al., (2023), Ciccullo et al., (2023), and Zailani et al. (2017)
Reluctance to change	High competition in today's business environment and rapid changes in PRM methods and their digitization have caused organizations to be risk-averse and prefer the current situation and have no desire for changes	Lysenko-Ryba and Zimon (2021), Frei et al. (2020), and Zailani et al. (2017)
Resistance to change	Managers evaluate the costs of making changes in PRM higher than its benefits and resist changes. Fear of failure causes managers to resist changes in PRM, as well	Zailani et al. (2017)
Lack of motivation	Consumers should have an incentive to return the product. The lack of motivation leads to the non-participation of consumers in PRM	Duong et al. (2022)
Consumer awareness	Consumers' lack of awareness of the benefits of recycling and the environment makes consumers unwilling to return the product	Ciccullo et al., (2023), Kumar et al. (2023), Ambilkar et al. (2022), and Lysenko-Ryba and Zimon (2021)
Long delivery distance	The long delivery distance makes the consumer reluctant to return the product	Ciccullo et al., (2023), Ambilkar et al. (2022), De Borba et al. (2021), Frei et al. (2020), and Pei and Paswan (2017),
Lack of communication with consumers	Communicating with consumers makes them await discounts and product return benefits. If there is no communication, consumers do not want to return the product	Gunasekara et al., (2023), Ciccullo et al., (2023), Karlsson et al. (2023), Lysenko-Ryba and Zimon (2021), and De Borba et al. (2021)

Table 2 (continued)

PRM barriers	Brief definition	References
Inappropriate products design	The product should be designed in such a way that consumers' awareness about recycling and the impact of returning the product will increase	Mishra et al. (2023), Kumar et al. (2023), Sandberg (2023), Agrawal et al., (2023b), Gunasekara et al., (2023), Ciccullo et al., (2023), Lysenko-Ryba and Zimon (2021), Farooque et al. (2019), Shaharudin et al. (2017), and Zailani et al. (2017)
Unfavourable quality of products	Unfavourable quality of products causes them not to be recycled. This causes the desire of customers to return products to decrease and they buy their products from other brands that meet the environmental goals	Sandberg (2023), Agrawal et al., (2023b), Ambilkar et al. (2022), Lysenko-Ryba and Zimon (2021), Wan et al. (2020), Frei et al. (2020), Lesmono et al. (2020), Shaharudin et al. (2017), Pei and Paswan (2017), and Zailani et al. (2017)
Absence of PRM policies	Policies and strategies that motivate consumers to return their products should exist in PRM	Karlsson et al. (2023), Ambilkar et al. (2022), Lysenko-Ryba and Zimon (2021), De Borba et al. (2021)(Robertson et al., 2020), Frei et al. (2020), Dzyabura et al. (2018), Pei and Paswan (2017), and Zailani et al. (2017)
Lack of support from senior managers	The lack of support of senior managers for PRM policies and their reluctance to implement product return projects makes the linear supply chain ineffective and economic, social and environmental goals are not achieved	Zailani et al. (2017)
Ambiguity of sustainability goals	Organizations would not show a desire to improve PRM and CSC performance If sustainability goals are unclear to them	Das and Dutta (2022), Zhang et al. (2021) Frei et al. (2020), and Zailani et al. (2017)

branch managers from the same company to identify ambiguities or redundancies; and (3) Incorporating feedback from the experts during the initial briefing session, where certain terms were clarified and revised to enhance understandability and ensure a shared interpretation of the factors. Through this iterative process, we ensured that the final list of barriers was comprehensible, contextually appropriate, and aligned with the experts' practical experience.

As Previous research has also shown that expert-based methodologies can be effective even with a small sample size, as the study's aim is not to generalize findings (Hashemi Petrudi et al., 2020). According to Liu et al. (2005), the number of experts varies according to the research topic and problem, although there is no single answer for the number of experts. Many scholars acknowledged that the experience and intuition of a small group of

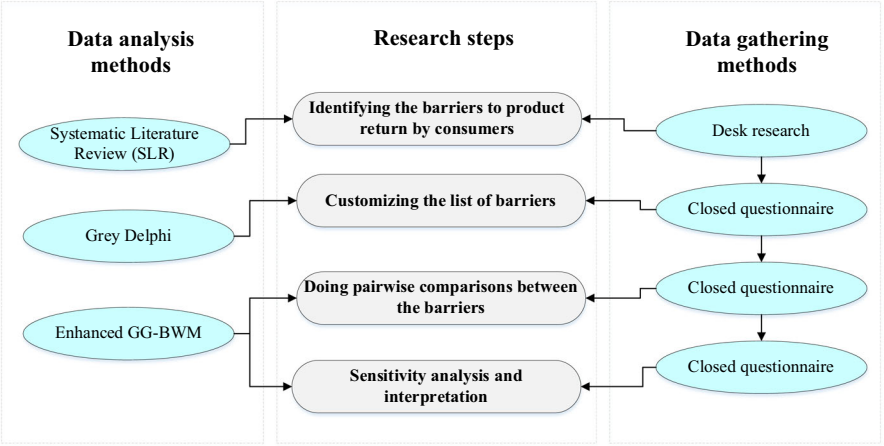

Fig. 1 Research Framework

Table 3 Experts profile

Expert ID	Experience	Position	Education		Gender	
			PhD	MA	F	M
E_1	10^+	Sales manager	*			*
E_2	20^+	Purchasing manager	*		*	
E_3	15^+	Procurement director	*		*	
E_4	15^+	Chief supply officer		*		*
E_5	10^+	Marketing director		*		*

MA MA/MSc/MEng etc., *F* Female, *M* Male

key managers lead to reliable and useful results. Contrary to statistical analysis, in decision-making approaches in the field of operations management, the number of experts between two and ten is sufficient, while more than ten experts cause inconsistency and disagreement among the data (Jafari-Sadeghi et al., 2022). The characteristics of the experts are shown in Table 3.

3.1 Grey Delphi

First, during the online meetings, the purpose and method of the research were explained to the experts, and then the Gray Delphi questionnaire was sent to the experts. The Gray approach was employed to deal with uncertainty in this study. The Gray approach categorizes the data as certain (white), insufficient (Grey), unknown (black). In the Grey Delphi, the Grey-white weight function is used to select evaluation indicators. The Grey Delphi method is as follows (Nguyen et al., 2023).

Step 1. Influential barriers are extracted from the literature.

Table 4 Linguistic scale and Grey number (Nguyen et al., 2023)

Linguistic Scale	Grey Number
No important (NI)	[0,0]
Low important (LI)	[0,1]
Medium important (MI)	[1,2]
High important (HI)	[2,3]
Very high important (VH)	[3,4]

Step 2. Questionnaires are designed and sent to experts. Experts answer them through the linguistic spectrum of Table 4.

Step 3. The linguistic variables are converted into Grey numbers, after the experts complete the questionnaire. In Grey theory, the exact values of the grey numbers are not known, but the interval (lowest and highest range) covers a value assumed to be almost known. A grey number is written as $\otimes a = \left[\underline{a}, \overline{a}\right]$, where $\underline{a}$ and $\overline{a}$ are the lower and upper limits, respectively. To integrate the experts' opinions, Eq. 1 is used.

$$\otimes G_i = \frac{\left(G_i^1 + \otimes G_i^2 + \cdots + \otimes G_i^h + \cdots + \otimes G_i^p\right)}{p} \tag{1}$$

where, $\otimes G_i$ is a Grey score of the factor i and p is the number of expert members.

Step 4. After summarising the opinions of experts, the Gray numbers in the range of $\otimes G = \left[G^L, G^R\right] = \left[G\prime \in G \middle| G^L \leq G\prime \leq G^R\right]$ are obtained. Equation 2 is employed to obtain crisp number.

$$\tilde{\otimes} G_i = \alpha \cdot G^L + (1-\alpha) \cdot G^R, \alpha = [0, 1] \tag{2}$$

Step 5. Factors are rejected or selected in this step. The threshold (λ) limit is taken from the average of all crisp numbers (mean of means) to finalise the factors (Hashemi Petrudi et al., 2020). Crisp numbers are compared with the threshold. If they are greater than the threshold, they are selected, otherwise, they are rejected.

3.2 An enhanced GG-BWM

After finalizing PRM barriers, a novel version of Grey group Best–Worst Method (BWM) is employed to rank them. BWM is invented by Rezaei (2015) and has fewer pairwise comparisons than other methods like analytical hierarchy process (AHP) and leads to answers with higher confidence and lesser inconsistencies. This method has attracted the attention of numerous researchers and has been used in various fields such as Kaizen projects (Amoozad Mahdiraji et al., 2023a, 2023b), collaborative consumption and sharing economy (Amoozad Mahdiraji et al., 2023a, 2023b), supply chain (Abdel-Basset et al., 2020), and higher education performance measurement (Hashemi Petrudi et al., 2022). The steps of BWM are as follows (Rezaei, 2015).

Step 1. A set of n criteria $\{C_1, C_2, \ldots, C_3\}$ are considered for evaluation.

Step 2: The best and worst criteria are determined in this step.

Step 3: The best criterion is compared with other criteria on a scale of 1 to 9. So, the best-to-others (BO) vector can be represented as $A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn})$.

Step 4: The worst criterion is compared with other criteria on a scale of 1 to 9. So, the others-to-worst (OW) vector can be represented as $A_B = (a_{1W}, a_{2W}, \ldots, a_{nW})$.

Step 5: In order to obtain optimal weights that the maximum absolute difference for all j is minimized of $\{|w_B - a_{Bj} \cdot w_j|, |w_j - a_{jw} \cdot w_w|\}$, a linear programming model should be presented as follows (Rezaei, 2016). Optimum weights are obtained by solving the following model.

$$\begin{aligned} &\min \xi \\ &s.t. \\ &\left|\frac{w_B}{w_j} - a_{Bj}\right| \le \xi, \quad \text{for all} \quad j \\ &\left|\frac{w_j}{w_W} - a_{jW}\right| \le \xi, \quad \text{for all} \quad j \\ &\sum_j w_j = 1 \\ &w_j \ge 0, \quad \text{for all} \quad j \end{aligned} \tag{3}$$

Applying the Grey set in BWM leads to more reliable results than the fuzzy set as evidenced by Petrudi et al. (2021). Moreover, the conventional BWM necessitates the resolution of model (3) for each expert individually, rendering it a time-intensive procedure. Contrastingly, the GG-BWM model introduced by Petrudi et al. (2021) derives factor weights by resolving a singular mathematical programming model. The GG-BWM is as follows:

$$\begin{aligned} &\min \sum_{k=1}^{p} w_k^E \xi_k \\ &\left|\overline{w}_B - \overline{a}_{Bj}^k \cdot \underline{w}_j\right| \le \xi_k, \quad j = 1, 2, ..., n, \quad k = 1, 2, ..., p \\ &\left|\underline{w}_B - \underline{a}_{Bj}^k \cdot \overline{w}_j\right| \le \xi_k, \quad j = 1, 2, ..., n, \quad k = 1, 2, ..., p \\ &\left|\overline{w}_j - \overline{a}_{jW}^k \cdot \underline{w}_W\right| \le \xi_k, \quad j = 1, 2, ..., n, \quad k = 1, 2, ..., p \\ &\left|\underline{w}_j - \underline{a}_{jW}^k \cdot \overline{w}_W\right| \le \xi_k, \quad j = 1, 2, ..., n, \quad k = 1, 2, ..., p \\ &\sum_{j=1}^{n} \otimes w_j = 1 \\ &\overline{w}_j \ge (1 + \varepsilon)\overline{w}_j \end{aligned} \tag{4}$$

where w_k^E represents the weight of the kth decision maker's judgment; and ξ_k stands for the inconsistency ratio for the kth decision maker. In this model, they considered the best and worst criteria to be the same for all decision makers. As it can be seen in the model, there is a unique $\overline{w}_B (upper\ bound\ of\ w_B)$, $\underline{w}_B$ *lower bound of* w_B, $\underline{w}_W$ *lower bound of* w_W, and $\overline{w}_W$ *upper bound of* w_W. w_B stands for the weight the best factor, and w_W represents the relative weight of the worst factor. The normalization constraint ($\sum_{j=1}^{n} \otimes w_j = 1$) includes the grey numbers and for solving the model it can be transformed into the two following constraints:

$$\sum_{j=1}^{n} \overline{w}_j \le (1 + \alpha) \tag{5}$$

$$\sum_{j=1}^{n} \overline{w}_j \geq (1-\alpha) \tag{6}$$

Petrudi et al. (2021) suggested to set the α to 0.2 provides satisfying results.

In practical application, we encountered challenges achieving consensus among our panel of experts regarding the identical best and worst barriers. Therefore, the proposed GG-BWM by Petrudi et al. (2021) was modified to consider independent set of the best and the worst factors for each expert like the original BWM. We have termed this evolved iteration of the GG-BWM as GG-BWM1, denoting the refined model in this manner:

$$\begin{aligned}
&\min \sum_{k=1}^{p} w_k^E \xi_k \\
&\left|\overline{w}_B - \overline{a}_{Bj}^k \cdot \underline{w}_j\right| \leq \xi_k, \quad j = 1, 2, ..., n, \quad k = 1, 2, ..., p \\
&\left|\underline{w}_B - \underline{a}_{Bj}^k \cdot \overline{w}_j\right| \leq \xi_k, \quad j = 1, 2, ..., n, \quad k = 1, 2, ..., p \\
&\left|\overline{w}_j - \overline{a}_{jW}^k \cdot \underline{w}_W\right| \leq \xi_k, \quad j = 1, 2, ..., n, \quad k = 1, 2, ..., p \\
&\left|\underline{w}_j - \underline{a}_{jW}^k \cdot \overline{w}_W\right| \leq \xi_k, \quad j = 1, 2, ..., n, \quad k = 1, 2, ..., p \\
&\sum_{j=1}^{n} \overline{w}_j \leq (1+\alpha) \\
&\sum_{j=1}^{n} \underline{w}_j \geq (1-\alpha) \\
&\overline{w}_j \geq (1+\varepsilon)\underline{w}_j
\end{aligned} \tag{7}$$

The second enhancement incorporated into the model involved the introduction of a "group-level inconsistency ratio" alongside the existing "individual inconsistency ratio (ξ_k)". We observed that that while ξ_k effectively gauges the consistency in an expert's judgments, both the GG-BWM and the original BWM models lack a measure of inconsistency at the group level or across experts' assessments. Additionally, the GG-BWM model lacked any constraints to regulate the disparity between the aggregated factor weights, and the individual expert-assessed weights. For instance, it is not clear to what extent the aggregated weight of the factors is close to the individual opinions of the experts. To address this limitation, inspired by the concept of introducing ξ in the original BWM model (Rezaei, 2016), a new variable namely, θ, was added, to manage the disparity between the aggregated factor weight, and the weights derived from each expert's judgements. For instance, considering the aggregated weight of factor 1 as w_1^A (where A stands for aggregated) and there are three experts in the panel, the individual expert-derived weights for factor 1 are denoted as w_1^{e1}, w_1^{e2}, and w_1^{e3}(where e represents experts). Consequently, we added the below constraints and aimed to minimise θ:

$$\left|w_1^A - w_1^{e1}\right| \leq \theta \tag{8}$$

$$\left|w_1^A - w_1^{e2}\right| \leq \theta \tag{9}$$

$$\left|w_1^A - w_1^{e3}\right| \leq \theta \tag{10}$$

Constraint 8 makes sure that there is minimum distance between w_1^A and w_1^{e1}; constraint 9 assures the minimum distance between w_1^A and w_1^{e2}; and constraint 10 assures the minimum distance between w_1^A and w_1^{e3} similarly. But, as we considered opinions as Grey numbers, the enhanced model of GG-BWM is reformulated as follows (GG-BWM2):

$$
\begin{aligned}
&\min \sum_{k=1}^{p} w_k^E \xi_k + \theta \\
&\left| \overline{w}_B^k - \overline{a}_{Bj}^k \cdot \underline{w}_j^k \right| \le \xi_k, \quad j = 1, 2, ..., n, \quad k = 1, 2, ..., p \\
&\left| \underline{w}_B^k - \underline{a}_{Bj}^k . \overline{w}_j^k \right| \le \xi_k, \quad j = 1, 2, ..., n, \quad k = 1, 2, ..., p \\
&\left| \overline{w}_j^k - \overline{a}_{jW}^k \cdot \underline{w}_W^k \right| \le \xi_k, \quad j = 1, 2, ..., n, \quad k = 1, 2, ..., p \\
&\left| \underline{w}_j^k - \underline{a}_{jW}^k \cdot \overline{w}_W^k \right| \le \xi_k, \quad j = 1, 2, ..., n, \quad k = 1, 2, ..., p \\
&\sum_{j=1}^{n} \overline{w}_j^k \le (1 + \alpha) \quad k = 1, 2, ..., p \\
&\sum_{j=1}^{n} \underline{w}_j^k \ge (1 - \alpha) \quad k = 1, 2, ..., p \\
&\overline{w}_j \ge (1 + \varepsilon) \underline{w}_j \\
&\left| w_j - \underline{w}_j^k \right| \le \theta, \quad j = 1, 2, ..., n, \quad k = 1, 2, ..., p \\
&\left| w_j - \overline{w}_j^k \right| \le \theta, \quad j = 1, 2, ..., n, \quad k = 1, 2, ..., p \\
&\sum_{j=1}^{n} w_j = 1
\end{aligned}
\tag{11}
$$

In this model, referred to as GG-BWM2, the addition of superscript k to all decision variables representing relative weights serves the purpose of ensuring minimal deviation between the aggregated weight and each individual weight calculated from the assessments provided by experts. Additionally, to account for the distinct weights assigned by each expert to factors, Grey normality constraints, akin to constraints 5 and 6 in the preceding model, are applied to all experts.

Furthermore, as previously discussed, constraints 8 and 9 are implemented to enforce minimal disparity between the aggregated weight and individual weights. The objective function is structured to minimise θ aligning with the aim of reducing the discrepancy between these weights.

3.3 Case description

In this study, an evaluation of Product Return Management (PRM) within an undisclosed Organization (referred to as Organization A to maintain confidentiality) is conducted. Established in 2007 in Iran, Organization A initiated its operations by producing barley biscuits and holds the distinction of being the inaugural recipient of the barley biscuit standard in Iran. Notably, the organization manufactures its products in packaging designed to enhance

customer convenience. As a manufacturer of (FMCGs), Organization A extends its market reach beyond Iran, exporting to countries such as Australia, various Asian nations, and European markets. Among its range of products, Organization A offers multi-cereal biscuits and multi-cereal biscuits incorporating edible nuts.

Furthermore, Organization A has devised a consumer-oriented initiative aimed at recycling biscuit boxes. Under this scheme, consumers are encouraged to return empty boxes of Organization A's products to designated retail outlets. In return for three empty boxes returned, consumers are offered a package of wholemeal biscuits or barley biscuits.

Roughly a year after the launch of this initiative, numerous challenges arose, hindering the company's efforts to effectively implement its circular initiative. Interviews were conducted with experts from various retailing stores situated in Mazandaran Province, Iran, serving as the impetus for commencing a research project on this issue. As noted by Mangla et al. (2018), here is a scarcity of research on challenges and barriers in implementing CSC management in developing nations. This study aligns with their recommendation to explore the barriers associated with a crucial process within CSCs—the return of products.

4 Results

A Grey Delphi questionnaire was designed and sent to experts after extracting 13 barriers to PRM in CSC through SLR. Then, the experts' opinions were collected, and linguistic variables were converted into Grey numbers. In the end, barriers were analyzed using Eq. 1 and 2 and are shown in Table 5.

To filter out the barriers, the threshold was taken from the average of crisp numbers (1.977). Reluctance to change, resistance to change, absence of PRM policies, and not supporting senior managers barriers were removed after applying the threshold, and 9 barriers were selected. The final barriers are shown in Table 6 along with their ID which were ranked based on the enhanced GG-BWM in the next step.

Table 5 Grey Delphi method results

No	PRM barriers	Overall grey weight	Crisp weight	Status
1	Lack of proper infrastructure	[2.2,3.2]	2.7	✓
2	Lack of expert staff	[1.6,2.6]	2.1	✓
3	Reluctance to change	[0.2,1]	0.6	×
4	Resistance to change	[0,0.4]	0.2	×
5	Lack of motivation	[2.6,3.6]	3.1	✓
6	Consumer awareness	[2.6,3.6	3.1	✓
7	Long delivery distance	[2.2,3.2]	2.7	✓
8	Lack of communication with consumers	[2.2,3.2]	2.7	✓
9	Inappropriate products design	[2.2,3.2]	2.7	✓
10	Unfavourable quality of products	[2.4,3.4]	2.9	✓
11	Absence of PRM policies	[0.2,0.6]	0.4	×
12	Not supporting senior managers	[0,0.8]	0.4	×
13	Ambiguity of sustainability goals for organizations	[1.6,2.6]	2.1	✓

Table 6 Final barriers to PRM in CSC

ID	PRM barriers	Crisp weight
PR_1	Lack of proper infrastructure	2.7
PR_2	Lack of expert staff	2.1
PR_3	Lack of motivation	3.1
PR_4	Consumer awareness	3.1
PR_5	Long delivery distance	2.7
PR_6	Lack of communication with consumers	2.7
PR_7	Inappropriate products design	2.7
PR_8	Unfavourable quality of products	2.9
PR_9	Ambiguity of sustainability goals for organizations	2.1

Pairwise comparisons of PRM barriers in CSC that were made through the enhanced GG-BWM are shown in Table 7. For example, according to expert number 3, the best (most important) barrier is consumer awareness (PR_4), whose value is [1,1] in the column of the matrix, and according to this barrier, the expert performs their pairwise comparisons to others. The worst (least important) barrier from this expert's point of view is ambiguity of sustainability goals for organizations (PR_9) the value above [5,7] indicates the preference for training (PR_4) [5,7] times over this barrier, and according to this barrier, other pairwise comparisons were made. Pairwise comparisons of other barriers were completed in the same way, as well.

After collecting experts' opinions, data analysis, and solving the model in Lingo 18, results were obtained in Table 8. According to the results, Lack of motivation (PR_3) was recognized as the most important barrier, and Lack of expert staff (PR_2) was recognized as the least important. This table shows the result of the initial scenario of GG-BWM1. In this scenario,

Table 7 Pairwise comparison

Best-to-others						Others-to-worst					
Expert	E_1	E_2	E_3	E_4	E_5	Expert	E_1	E_2	E_3	E_4	E_5
Best PR	PR_4	PR_3	PR_4	PR_4	PR_3	Worst PR	PR_2	PR_2	PR_9	PR_5	PR_2
PR_1	[2,3]	[2,4]	[2,3]	[3,4]	[4,5]	PR_1	[2,4]	[5,7]	[4,5]	[6,7]	[3,4]
PR_2	[7,9]	[6,8]	[2,3]	[3,5]	[5,7]	PR_2	[1,1]	[1,1]	[2,3]	[5,7]	[1,1]
PR_3	[2,3]	[1,1]	[2,3]	[2,3]	[1,1]	PR_3	[2,3]	[6,8]	[4,5]	[5,6]	[5,7]
PR_4	[1,1]	[3,4]	[1,1]	[1,1]	[2,3]	PR_4	[7,9]	[5,6]	[5,7]	[6,8]	[3,4]
PR_5	[3,5]	[4,6]	[4,6]	[6,8]	[2,3]	PR_5	[5,7]	[5,6]	[3,4]	[1,1]	[2,4]
PR_6	[2,4]	[2,5]	[4,5]	[3,5]	[3,4]	PR_6	[6,7]	[3,4]	[3,4]	[4,5]	[4,5]
PR_7	[6,7]	[3,4]	[5,6]	[5,7]	[2,3]	PR_7	[5,7]	[3,4]	[4,5]	[4,6]	[4,6]
PR_8	[6,8]	[2,4]	[2,3]	[5,6]	[2,3]	PR_8	[7,8]	[3,4]	[2,3]	[2,3]	[2,3]
PR_9	[5,7]	[4,5]	[5,7]	[3,4]	[3,4]	PR_9	[4,6]	[6,7]	[1,1]	[5,6]	[3,5]

Table 8 Results of GG-BWM1 (initial scenario)

ID	PRM Barriers	Grey weight $(\underline{W}_j, \overline{W}_j)$	Whitened weight	Normalized weight	Rank
PR_1	Lack of proper infrastructure	(0.1095, 0.1106)	0.1100	0.2234	3
PR_2	Lack of expert staff	(0.0049, 0.0050)	0.0050	0.0101	9
PR_3	Lack of motivation	(0.1596, 0.2281)	0.1939	0.3936	1
PR_4	Consumer awareness	(0.1368, 0.1596)	0.1482	0.3010	2
PR_5	Long delivery distance	(0.0052, 0.0053)	0.0052	0.0106	8
PR_6	Lack of communication with consumers	(0.0096, 0.0097)	0.0096	0.0195	4
PR_7	Inappropriate products design	(0.0068, 0.0069)	0.0069	0.0140	5
PR_8	Unfavourable quality of products	(0.0060, 0.0076)	0.0068	0.0138	7
PR_9	Ambiguity of sustainability goals for organizations	(0.0068, 0.0069)	0.0069	0.0140	5
$\xi = 0.319$					

for the sake of simplicity, a singular consistency ratio was employed and integrated into the objective function.

4.1 Sensitivity analysis

To validate the proposed approach, a two-phase sensitivity analysis has been performed. In the first step, the sensitivity of the weights to the judgments of pairwise comparisons was investigated. For this purpose, different upper and lower bounds of grey judgments were considered as shown in Table 9 and their effects on the final weights were investigated. It has been observed that the final weights of the criteria change as the judgments of pairwise comparisons change. Two different sets of best and worst criteria were considered, and calculations were performed with experimental data.

In the second phase, a sensitivity analysis was undertaken to assess the influence of experts' judgmental weights on the final weights assigned to the barriers. 11 scenarios were investigated as shown in Table 9. In the first scenario, the model was implemented solely considering different inconsistency ratios, with equal relative weights attributed to each expert, and the following scenarios varied different weights for the judgements of each expert. In the first, third, sixth and ninth scenarios, lack of motivation was identified the most important barrier while in the second, fourth, fifth, seventh, eighth, tenth and eleventh scenarios, consumer awareness took precedence as the most important barrier. Also, lack of expert staff is the least important barrier across all scenarios except for the eleventh scenario in which unfavourable quality of products was identified as the least important one.

To compute the group-level inconsistency ratio, our proposed GG-BWM2 model was utilised. To gauge its efficacy, the results from GG-BWM2 were compared against those obtained from GG-BWM1 (initial scenario) and GG-BWM1 (scenario 1), as presented in

Table 9 Different scenarios for sensitivity analysis

		S*1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
Relative importance	PR_1	0.022	0.212	0.018	0.224	0.212	0.017	0.018	0.201	0.161	0.202	0.024
	PR_2	0.012	0.007	0.007	0.007	0.007	0.007	0.008	0.009	0.008	0.009	0.013
	PR_3	0.481	0.330	0.604	0.294	0.330	0.574	0.376	0.342	0.447	0.295	0.421
	PR_4	0.397	0.393	0.272	0.420	0.393	0.308	0.500	0.385	0.299	0.434	0.455
	PR_5	0.013	0.007	0.018	0.007	0.007	0.017	0.023	0.009	0.01	0.012	0.016
	PR_6	0.024	0.017	0.022	0.015	0.017	0.022	0.021	0.015	0.025	0.012	0.021
	PR_7	0.018	0.012	0.022	0.013	0.012	0.021	0.019	0.014	0.021	0.009	0.017
	PR_8	0.017	0.012	0.018	0.012	0.012	0.018	0.017	0.013	0.016	0.012	0.012
	PR_9	0.022	0.011	0.019	0.009	0.011	0.017	0.019	0.012	0.013	0.015	0.021
Inconsistency ratio	ξ_1	0.313	0.221	0.473	0.231	0.221	0.442	0.543	0.221	0.197	0.198	0.178
	ξ_2	0.365	0.555	0.14	0.629	0.555	0.202	0.282	0.612	0.265	0.276	0.213
	ξ_3	0.313	0.221	0.475	0.161	0.221	0.442	0.192	0.235	0.572	0.274	0.217
	ξ_4	0.313	0.221	0.475	0.231	0.221	0.442	0.213	0.276	0.243	0.598	0.223
	ξ_5	0.216	0.365	0.008	0.427	0.365	0.008	0.276	0.199	0.265	0.245	0.672
Scenario description	Scenario1: equal relative weights experts											
	Scenario2: different weights for experts: (E1:0.4, E2: 0.15, E3: 0.15, E4: 0.15, E5: 0.15)											
	Scenario3: different weights for experts: (E1:0.15, E2: 0.4, E3: 0.15, E4: 0.15, E5: 0.15)											
	Scenario4: different weights for experts: (E1:0.15, E2: 0.15, E3: 0.4, E4: 0.15, E5: 0.15)											
	Scenario5: different weights for experts: (E1:0.15, E2: 0.15, E3: 0.15, E4: 0.4, E5: 0.15)											
	Scenario6: different weights for experts: (E1:0.15, E2: 0.15, E3: 0.15, E4: 0.15, E5: 0.4)											
	Scenario7: different weights for experts: (E1:0.04, E2: 0.24, E3: 0.24, E4: 0.24, E5: 0.24)											
	Scenario8: different weights for experts: (E1:0.24, E2: 0.04, E3: 0.24, E4: 0.24, E5: 0.24)											

Table 9 (continued)

	S* 1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
Scenario9: different weights for experts: (E1:0.24, E2: 0.24, E3: 0.04, E4: 0.24, E5: 0.24)											
Scenario10: different weights for experts: (E1:0.24, E2: 0.24, E3: 0.24, E4: 0.04, E5: 0.24)											
Scenario11: different weights for experts: (E1:0.24, E2: 0.24, E3: 0.24, E4: 0.24, E5: 0.04)											

*S stands for scenario

Table 10 comparison between GG-BWM2 and GG-BWM1

	ID	List of barriers	GG-BWM1 Initial scenario	GG-BWM1 Scenario 1	GG-BWM2
Relative importance	PR_1	Lack of proper infrastructure	0.2234	0.0219	0.1374
	PR_2	Lack of expert staff	0.0101	0.0120	0.0024
	PR_3	Lack of motivation	0.3936	0.4811	0.1845
	PR_4	Consumer awareness	0.3010	0.3965	0.1677
	PR_5	Long delivery distance	0.0106	0.0126	0.1045
	PR_6	Lack of communication with consumers	0.0195	0.0240	0.1199
	PR_7	Inappropriate products design	0.0140	0.0179	0.0032
	PR_8	Unfavourable quality of products	0.0138	0.0169	0.1246
	PR_9	Ambiguity of sustainability goals for organizations	0.0140	0.0219	0.1059
Inconsistency ratio	ξ		0.319	×	×
	θ		×	×	0.0081
	ξ_1		×	0.313	0.1012
	ξ_2		×	0.365	0.0082
	ξ_3		×	0.313	0.0068
	ξ_4		×	0.313	0.0098
	ξ_5		×	0.216	0.0049

Table 10. In the modelling of GG-BWM, the relative weight of each expert's judgment was uniformly considered, akin to scenario 1.

For comparing the individual-level inconsistency against group-level one, the coefficient of θ was set at 1, while the coefficient of each ξ_1 to ξ_5 was set at 0.2 each. for comparing these two measures, we need to sum ξ_1 through ξ_5 and compare it to the amount of θ. This analysis revealed a considerably lower level of group-level inconsistency in contrast to individual-level inconsistencies. Upon scrutinising the relative weights assigned to the barriers, it is apparent that GG-BWM2 exhibits greater discriminatory power, enabling a more effective prioritisation of factors, particularly noticeable in the relative weights of barriers 1, 5, and 6. While the primary barrier remains "lack of motivation," GG-BWM2 demonstrates more pronounced discrimination among other barriers, showcasing its superior ability to discern and prioritise factors.

As shown in Table 10, the group-level inconsistency is 0.0081. Our findings reveal some interesting insights. Allocating different weights to each expert results in varying group-level inconsistency ratios. Certain experts contribute to lower group inconsistency ratios, likely because their judgments align closely with the group average. These individuals, whom we refer to as "consensus-builder," help facilitate agreement within the group due to their similar views. Conversely, when higher relative weight is assigned to certain individuals, it sometimes

Table 11 θ in enhanced GG-BWM regarding different weights for experts' opinions

Scenario description (relative weight for experts' opinions)	θ
Scenario1: equal relative weights are considered for each expert (ξ_1 to ξ_5)	0.0081
Scenario2: different weights for experts: (E1:0.4, E2: 0.15, E3: 0.15, E4: 0.15, E5: 0.15)	**0.0062**
Scenario3: different weights for experts: (E1:0.15, E2: 0.4, E3: 0.15, E4: 0.15, E5: 0.15)	0.0098
Scenario4: different weights for experts: (E1:0.15, E2: 0.15, E3: 0.4, E4: 0.15, E5: 0.15)	0.0088
Scenario5: different weights for experts: (E1:0.15, E2: 0.15, E3: 0.15, E4: 0.4, E5: 0.15)	**0.0103**
Scenario6: different weights for experts: (E1:0.15, E2: 0.15, E3: 0.15, E4: 0.15, E5: 0.4)	0.0076
Scenario7: different weights for experts: (E1:0.04, E2: 0.24, E3: 0.24, E4: 0.24, E5: 0.24)	0.0089
Scenario8: different weights for experts: (E1:0.24, E2: 0.04, E3: 0.24, E4: 0.24, E5: 0.24)	0.0093
Scenario9: different weights for experts: (E1:0.24, E2: 0.24, E3: 0.04, E4: 0.24, E5: 0.24)	0.0082
Scenario10: different weights for experts: (E1:0.24, E2: 0.24, E3: 0.24, E4: 0.04, E5: 0.24)	0.0078
Scenario11: different weights for experts: (E1:0.24, E2: 0.24, E3: 0.24, E4: 0.24, E5: 0.04)	0.0095

leads to higher group-level inconsistency. We refer to such individuals as "dissenters," whose judgments deviate significantly from the group's average, often causing greater divergence during the decision-making process. Between these two extremes—consensus-thinkers and dissenters—are individuals we call "swing-thinkers," whose judgments fluctuate between consensus and dissent.

This initial finding prompted us to conduct sensitivity analysis on the parameter θ with respect to changes in experts' relative weights. As shown in Table 11, in scenario 2, when expert 1 holds the highest relative weight, the lowest group-level inconsistency (0.0062) occurs. In contrast, in scenario 5, when expert 4 holds the highest relative weight, the group-level inconsistency reaches its peak (0.0103). We refer to expert 1 as the "consensus-builder" and expert 4 as the "dissenter." The remaining experts can be considered "swing thinkers" as when they are assigned the highest relative weight, the group-level inconsistency falls between these two extremes.

5 Discussion

The relative importance of PRM barriers in CSC is shown in Table 8. In this study, PRM was investigated and evaluated in a real case of FMCGs retail of organization A. FMCGs are widely accessible to society and play a critical role in the CSC cycle. Their recovery and recycling have become more essential than ever, as they are consumed rapidly and need to re-enter the cycle promptly after use. Hence, the study centred on FMCGs due to their imperative role in achieving circular economy objectives. Enhancing PRM performance within the FMCG sector holds the potential to actualise these multifaceted goals. Through retail stores, organizations can be more in touch with consumers and understand their opinions and tastes better. There are many potentials in FMCGs through which the performance of organizations can be improved and the effectiveness and efficiency of PRM and CSC can be increased.

Organization A introduced an incentive scheme, offering rewards to encourage consumers to return used products. However, the initiative faced significant internal challenges. Post-implementation interviews with experts revealed two key reasons for its failure: poor supply

chain coordination and insufficient communication with retail sellers, which ultimately weakened consumer motivation to return the products. One interviewee emphasized that the company failed to fulfil its promise of exchanging one new product for three returned items, largely due to inadequate coordination with resellers. Furthermore, the lack of clear distinction between the responsibilities of the company and its resellers in delivering the free replacement product compounded the issue. When customers visited retail stores to collect their bonus products, some resellers were unaware of the campaign. At times, there was insufficient stock to meet customer demand, requiring retailers to replenish inventory, often resulting in extended lead times.

Additionally, one expert noted that "*consumer efforts to return goods were impeded by Organization A's failure to communicate effectively with retailers, resulting in sellers not accepting the returned products*". Consequently, consumer motivation dwindled, adversely impacting the organization's product sales. Furthermore, despite having knowledgeable employees, Organization A's hierarchical structure and communication gaps hindered the dissemination of the plan to retailers, leading to the sellers' refusal to accept consumers' returned goods.

According to experts of this study, motivating consumers increases their participation in product return projects, which was confirmed in some studies (e.g.Ratay & Mohnen, 2022; Simpson et al., 2019). Based on Zhou et al. (2023), any kind of return on the product needs motivation. Motivating consumers can be effective as a policy in PRM (Zhang et al., 2023). Creating motivation can be made through attractive offers (Bürger & Kleinert, 2021), appropriate product design (Rea, 2023), and quality enhancement (Malek et al., 2020). However, unlike some related studies, this study found that good infrastructure plays a key role in motivating customers to return used products. According to the experts, some customers, despite being aware of the product return scheme, were hesitant to return used packages to the store as they felt embarrassed due to their social status. This aligns with Gonella et al. (2024), who found that even in developed countries, there remains a significant gap between awareness and behavior towards circularity. Various factors, such as consumers' age, education, and social norms, influence and mediate the relationship between sustainability awareness and customers' circular behavior.

Customer awareness is another factor that can increase consumer participation in product return projects. The experts of this study believed that "*many consumers do not know about the environmental goals, recycling, and recovery of products*". According to Kamal et al. (2022), consumers' awareness of environmental goals, recycling, and recovery of products happens gradually, while FMCGs enter the recycling cycle and recover faster after consumption. Consumers should be aware that there is still added value in the consumed product (Ylä-Mella et al., 2022).

This study has both theoretical and practical implications. From a theoretical perspective, it provides conceptual and methodological contributions. On the practical side, it presents insights for supply chain managers. These implications are discussed in detail in the following section.

5.1 Implications to theory

5.1.1 Methodological contributions

From a methodological standpoint, we enhanced a novel multi-criteria decision-making (MCDM) method based on the GG-BWM, marking one of the first attempts to account

for both individual-level and group-level inconsistency ratios. To our knowledge, this feature has not been studied before. Additionally, we contribute to the MCDM literature, particularly in relation to the Best–Worst Method (BWM) introduced by Rezaei (2015). The group-level inconsistency ratio offers intriguing possibilities for future research. One of the key contributions of the group-level inconsistency ratio is its ability to be compared with individual inconsistency ratios, enabling an assessment of the influence of individual judgments on the overall (group-level) inconsistency ratio. For example, by analysing the impact of individual judgments on the group-level inconsistency ratio, we can propose a novel framework for classifying decision-makers within a group decision-making process. This research aligns with several future research recommendations made by Tang and Liao (2021), who advocated for the development of more operational research (OR) models to address group decision-making problems. Specifically, our study incorporates consensus measures, such as the group-level inconsistency ratio, as suggested in their work. Our findings suggest that at least three clusters of experts can be identified in a group decision-making context using our enhanced GG-BWM: (1) *consensus-builders*, (2) *dissenters*, and (3) *swing thinkers*. Consensus-builders are individuals whose opinions closely align with the group's average judgements, and the group tends to reach consensus around their views (as seen in our case study with expert 1). Dissenters are experts who act as outliers, challenging the group's thinking with critical and often creative perspectives (as seen with expert 4). The remaining experts are referred to as swing thinkers, who typically follow the majority or individuals without exerting significant influence on the group's decision-making process. When the highest weights are assigned to the opinions of consensus builders, the group-level inconsistency ratio is at its lowest. Conversely, assigning the highest weights to dissenters results in the highest inconsistency ratio. For the remaining experts, referred to as swing thinkers, assigning them the highest relative weights produces a group-level inconsistency ratio that falls between the maximum and minimum values observed in the previous two scenarios. This is another contribution of our study, and we believe it presents valuable opportunities for future research in the MCDM literature. Moreover, an additional contribution of the enhanced GG-BWM is its efficiency. By solving a single mathematical programming model, we facilitate group decision-making without needing to run individual models for each expert, as required in Rezaei's (2015) approach. The proposed enhanced GG-BWM is not only more efficient but also simplifies group decision-making by requiring the solution of just one mathematical programming model. This contrasts with previous extensions of the group BWM, such as Ahmad et al. (2021) and Safarzadeh et al. (2018). For instance, in Ahmad et al. (2021), an independent mathematical programming model must be solved for each expert. Similarly, while Safarzadeh et al. (2018) offer a single model to consolidate experts' opinions, additional calculations are needed to measure the group-level inconsistency ratio, adding to the complexity.

5.1.2 Conceptual contributions

From a conceptual viewpoint, this study is among the first to systematically review and analyze the barriers to product returns in a CSC within the retail industry. To our knowledge, pairwise comparisons of these factors have not previously been considered for the purpose of prioritisation. As such, this study sits at the intersection of CSC literature and MCDM literature, contributing to both fields. In circular supply chains, circular consumer behavior plays a pivotal role in enhancing resource efficiency and facilitating the flow of circular value (Gomes et al., 2022). While some studies, such as Gomes et al. (2022), have examined

circular behavior across multiple phases of consumption systems, this study focuses specifically on the post-utilisation phase of product consumption within circular supply chains. An interesting finding of this study is the relevance of psychological theories, such as the Theory of Planned Behavior, in analysing consumers' circular behavior. Our results indicate that, in addition to consumers' motivations and positive attitudes towards product returns, providing suitable and convenient infrastructure for product returns is paramount. However, we found subjective norms to be less significant. This may be attributed to cultural factors influencing sustainable awareness and behavior in developing countries. As Gaur et al. (2019) highlight, consumers in developing countries often exhibit more utilitarian buying behavior. In other words, individuals from diverse socio-economic and cultural backgrounds perceive and engage with sustainable practices differently. This underscores the importance of tailoring strategies to promote circular consumer behavior based on cultural and regional contexts. Additionally, as mentioned before there is a substantial gap between the circularity awareness of the customers and their circular behavior. Theories in the field of consumer behavior could be utilised to explore this issue in greater depth. This study highlights the significant role of infrastructure (both physical and non-physical) in facilitating the product return process. However, further research is needed to bridge this gap by considering relevant factors to provide a more comprehensive explanation.

5.2 Managerial implications

From a managerial perspective, this study highlights the importance of offering clear incentives to customers for returning used products or packaging and underscores the significance of enhancing the customer experience during the return process. The findings identify key barriers to product returns, including a lack of motivation, limited customer awareness, and insufficient infrastructure. Addressing these challenges is crucial for improving participation in product return projects and advancing the performance of CSCs. Social media can serve as a powerful tool for organizations to interact with their customers, understand their preferences, and produce more customer-friendly products (López et al., 2022). By leveraging social media platforms, organizations can also boost customer motivation to participate in product return schemes and encourage product purchases. Additionally, advertising plays a pivotal role in raising consumer awareness about the recycling and recovery of FMCGs (Sesar et al., 2022). Incorporating information about recycling benefits into product design can further enhance consumer awareness and promote sustainable behaviors (Shi et al., 2022). Alongside marketing campaigns aimed at increasing customer awareness and emphasising the benefits of returning products, it is essential to provide the necessary infrastructure to enable customers to return their used products conveniently and efficiently. As this study highlights, a seamless and well-designed return system can significantly influence customer participation. Supply chain managers must ensure that customers can complete the return process effortlessly, while preserving their social status. For example, implementing self-service return kiosks could streamline the return process by allowing customers to scan the product and use their customer loyalty or club cards to finalise the transaction. Such systems minimise errors, reduce customer effort, and contribute to a more positive and engaging return experience. By addressing these aspects, organizations can bridge the gap between customer awareness and circular behavior, advancing both sustainability and operational goals.

6 Conclusions and future research

This study examined the barriers to Product Return in CSCs. To identify these barriers, a SLR was conducted, focusing on existing research in PR and CSC. The barriers identified were then refined using the Grey Delphi method. Based on the Grey Delphi results, barriers such as reluctance to change, resistance to change, absence of PRM policies, and lack of support from senior managers were excluded. The remaining barriers—lack of proper infrastructure, lack of expert staff, lack of motivation, low consumer awareness, long delivery distances, poor communication with consumers, inappropriate product design, unfavourable product quality, and unclear sustainability goals for organizations—were prioritised using the enhanced Grey Group Best–Worst Method (GG-BWM). Earlier sections discussed the methodological and conceptual contributions of this study.

This study offers a range of theoretical and practical insights, with implications for both academia and industry. The enhanced GG-BWM method proposed in this research not only improves the efficiency of group decision-making processes but also addresses uncertainties more effectively. Furthermore, this study highlights the critical barriers to product returns in CSCs, offering actionable insights for supply chain managers, policymakers, and practitioners. Building on the findings, several avenues for future research are identified:

1. Testing the Enhanced GG-BWM Method. Future studies could further test the enhanced GG-BWM to assess its effectiveness in managing uncertainties and supporting group decision-making scenarios. This method presents intriguing possibilities for advancing group decision-making methods. For example, future research could explore integrating group-level inconsistency ratios into other MCDM methods, such as AHP and ANP, to generate additional managerial insights. A compelling direction would involve comparing various MCDM methods to determine which achieves lower group-level inconsistency ratios while evaluating the effectiveness of consensus-builders, dissenters, and swing thinkers. Moreover, future studies could develop and test alternative group-level inconsistency ratios, considering the classifications of decision-makers.
2. Exploring drivers and enablers of product return. While this study focused on barriers to product returns in CSCs, future research could investigate the drivers and enablers of product return within these supply chains. Researchers might explore alternative approaches to account for uncertainty, such as Pythagorean Fuzzy Sets (PFSs) or Intuitionistic Fuzzy Sets (IFSs). Additionally, methods like DEMATEL could be employed to identify and analyze cause-and-effect relationships among barriers, while tools like Fuzzy Cognitive Mapping (FCM) and Total Interpretive Structural Modelling (TISM) could uncover structural relationships and interdependencies among these barriers.
3. Government interventions and citizen engagement. As suggested in the literature, government interventions are a key driver in transitioning from a linear to a circular economy (Govindan & Hasanagic, 2018). Given the focus of this study on the commercial sector and retail experts, future research could explore government support for citizens participating in product return schemes and circular behaviors. Moreover, studies could examine the interplay between circular cities and circular supply chains to provide deeper insights into the roles of governments and citizens at various levels as discussed in Ortega Alvarado and Pettersen (2023).
4. Enhancing the efficiency of the proposed GG-BWM. Although the proposed GG-BWM is more efficient than previous extensions of group BWM, there remains room for further improvement. One avenue for research is reducing the number of pairwise comparisons required. As Rezaei (2015) highlighted, fewer comparisons can significantly reduce inconsistencies and streamline the decision-making process. While simplified methods,

such as Simplified AHP (Leal, 2020), have made progress in this area, more sophisticated approaches are needed. Future studies could explore the feasibility of allowing experts to select the sequence of pairwise comparisons and analyze the impact on the final weights of factors. Questions worth investigating include: Do factor weights vary significantly when experts begin with different sets of pairwise comparisons? and how would expert judgments change if they were exposed to the opinions of other panel members? Round-based approaches to achieving consensus could also be examined for their applicability to methods like GG-BWM.

5. Replication in developed economies. As this research was conducted in a developing country, future studies could replicate it in developed countries to identify similarities and differences in barriers and enablers. This would provide a broader understanding of product return management in diverse economic contexts. For instance, researchers could explore the primary barriers to product returns in developed countries and assess how higher levels of awareness influence customers' circular behaviors.

By addressing these research opportunities, future studies can extend the theoretical and practical contributions of this work, supporting the broader adoption of circular economy principles in various sectors and economic contexts.

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Declarations

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

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