Barriers to circular economy adoption in MSMEs: a WINGS analysis of challenges in developing economies

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Abstract

The transition to a circular economy (CE) is a crucial global goal aimed at promoting sustainable production and consumption. However, its adoption among Micro, Small, and Medium Enterprises (MSMEs) in developing economies remains constrained by multiple barriers. This study builds upon prior research that identified sixteen key barriers to CE adoption through a systematic literature review. Employing the Weighted Influence Non-linear Gauge System (WINGS) method, the study ranks the barriers in terms of their internal strength as well as their intensity to influence other barriers in the specific context of MSMEs. Expert evaluations indicate that lack of investment support, financial constraints, lack of resource efficiency, inadequate infrastructure, and limited potential knowledge are the most influential barriers. The WINGS analysis also reveals that lack of investment support and lack of information are the two primary barriers affecting the greatest number of other barriers. Hence, the findings of our study suggest the urgent need for targeted policy interventions to enhance financial capacity, knowledge dissemination, and infrastructural support, collectively facilitating MSMEs' transition to CE practices. This study contributes to the literature by identifying and prioritising the key barriers, as well as identifying the interconnectedness among them, which serves as a guide in order to design effective strategies supporting MSMEs in overcoming CE adoption barriers, thereby fostering sustainable economic growth in developing economies.

Keywords: Barriers, Circular Economy, Developing Economies, MSMEs, WINGS

JEL Classification: O31, C44, Q5, M13, R19

1 Introduction

Micro, Small, and Medium-Sized Enterprises (MSMEs) constitute a significant portion of the business landscape, representing around 90% of global enterprises and contributing over 50% of employment [1]. In emerging nations, MSMEs significantly contribute to economic development and job creation, accounting for over 70% of formal employment [1]. However, they contribute

disproportionately to environmental degradation due to limited access to sustainable technologies and practices. This paradox raises an urgent question: how can the world's most numerous businesses embrace circular economy (CE) principles to support global sustainability goals? In this context, MSMEs must re-evaluate their operational strategies for the utilisation of limited resources and materials and the reengineering of their production processes [2]. While not directly connected to the CE, MSMEs have become progressively aware of the advantages related to resource efficiency [3].

The concept of CE has become increasingly important to policymakers, businesses, and academics due to consumption patterns, rapid global population growth, and fast depletion of natural resources [4]. However, before substituting the conventional linear economy, it is important to comprehensively assess every aspect of the CE principles [5]. A linear economy, which follows a "take, make, use, and dispose" approach, is based on the continuous consumption of limited natural resources, which eventually leads to resource depletion [6, 7]. According to Luttenberger [8], the main problems associated with a linear economy are excessive waste, environmental degradation, and inefficiencies that contradict sustainable development goals. In response to these limitations of the traditional linear economy model, the concept of a CE is gaining more attraction as a means to shift toward sustainable, low-carbon, resource-efficient, and competitive economic systems [9].

According to Kirchherr et al. [10] and Walters et al. [11], CE is a regenerative model that reduces resource input and minimises waste, emissions, and energy loss by slowing, closing, and narrowing material and energy cycles. This process turns waste into commercially valuable resources utilising a variety of waste management tactics such as repairing, reusing, and recycling, providing multiple benefits to both firms and society. These benefits include supply chain optimisation, reduction of resource price fluctuations, improved customer relations, and the establishment of new job opportunities [12, 13]. Numerous MSMEs have effectively adopted circular ideas and are reaping their benefits. For instance, Phool.co, an Indian start-up, converts floral waste from temples into eco-friendly incense sticks and biodegradable packaging materials, effectively turning waste into a revenue-generating product while supporting rural women through employment. Similarly, GreenJams, a cleantech social enterprise, manufactures Agrocrete, a carbon-negative building material made from agricultural waste and industrial by-products, thereby addressing both waste management and the need for sustainable construction materials. These real-world Indian

examples highlight how MSMEs can become key agents of circular innovation while achieving economic and environmental goals.

However, there is still a dearth of research in this field, even though firms are increasingly inclined to adopt CE practices [14]. CE's implementation is especially concerning for MSMEs because such firms consistently face financial, human, and infrastructure constraints. Moreover, at times, these MSMEs have a limited understanding of the environmentally friendly and sustainable practices they must follow [15, 16]. Although several studies have identified many barriers hindering the effectiveness of CE practices in MSMEs and contributing to their delayed progress [2, 3, 10, 17, 18], there is very few comprehensive and rigorous empirical research in this area, especially in developing countries [19–21]. Hence, the adoption of CE techniques in MSMEs in emerging economies is still in its infancy phase, both in terms of scholarly investigation and real-world implementation.

Existing research on this topic primarily involves surveys or bibliometric analyses, with a focus mainly on developed countries. While some studies have investigated the barriers MSMEs face when adopting CE practices, there exists hardly any research exploring how these barriers interrelate, particularly in developing economies. This paper is an extension of our previous work [22], where we conducted a systematic literature review to identify factors influencing CE adoption in MSMEs. Based on research from both developed and developing nations, the study identified 16 barriers to CE adoption and 19 enablers, with financial constraints being the main barrier and technical advancements being a crucial enabler. Upon building on these findings, the current paper seeks to fill the gap in understanding the interrelationships among these barriers within developing economies. We utilise the Weighted Influence Non-linear Gauge System (WINGS) methodology, a comprehensive approach that uniquely assesses both the intensity of influence and the overall significance of each barrier. This method offers a more in-depth and applicable analysis than traditional barrier assessment methods. Specifically, the study aims to identify the primary barriers hindering CE adoption in MSMEs in developing regions and examine their contextual interrelationships. Consequently, the research questions were formulated: (RQ1) What are the primary barriers keeping MSMEs in developing nations from implementing CE principles? (RQ2) How are these barriers contextually interrelated? This study contributes to the growing body of research on CE practices by not only identifying major barriers but also by

providing insights into how these barriers are interconnected. This knowledge can assist stakeholders in assessing their readiness for the successful implementation of CE practices.

The remainder of the paper is organised as follows: Sec 2 provides a comprehensive analysis of the systematic literature study on the barriers to the adoption of CE ideas in MSMEs; Sec 3 outlines the research methodology; Sec 4 describes the process of collecting and analysing data; Sec 5 presents the results; Sec 6 deals with discussion and policy implications; and lastly, Sec 7 offers the study's conclusion and limitations.

2 Prior literature

2.1 CE notion

The principles of the CE are not recent; rather, Pearce and Turner first introduced the term in academic literature in the early 1990s. Under this perspective, the authors acknowledge that the connection between the environment and the economy extends beyond a simple linear interdependence. Many studies criticised the traditional linear economy model, which is characterised by the 'take-make-dispose' paradigm, and introduced a restorative, regenerative system where resource use is minimised and materials are cycled back into production loops [23–25]. Kirchherr et al. [10] examined and analysed 114 different definitions of the CE, highlighting the prevailing ambiguity surrounding the concept and reinforcing the argument that a universally accepted definition is lacking. However, despite these definitional inconsistencies, the concept has gained significant momentum and interest from policymakers, firms, and academicians because of its significant benefits to sustainable economic development [26–28]. Furthermore, critics argue that a significant portion of the literature lacks substantial empirical support, especially regarding the implications of CE in both developed and developing countries, resulting in inconsistent policy recommendations.

2.2 CE principles in the MSMEs of developing economies.

MSMEs hold a vital position in the international economy as they contribute to a large part of the total job creation and production activities [29–32]. In the context of developing countries, their role is even more crucial as engines of job creation, regional development, and poverty alleviation [33, 34]. Yet, their operational characteristics—limited financial capacity, informal structures, and

individualised decision-making—set them apart from larger enterprises [3, 35]. While not directly connected to CE, MSMEs have been progressively aware of the advantages related to resource efficiency [3]. Geissdoerfer et al. [6] found that the CE can assist MSMEs in cutting production costs by encouraging reuse and recycling. By using fewer raw materials, MSMEs can save on waste disposal and material procurement. A study by Kirchherr et al. [36] indicates that MSMEs can create new products and services that align with the requirements of a CE, facilitating access to new markets and fostering the development of more sustainable supply chains. While transitioning to a CE may benefit MSMEs, those in emerging countries encounter dual pressures. The absence of conducive conditions is intrinsic to emerging markets, together with the obstacles posed by their limited scale and resource scarcity, which may constrain their grassroots initiatives [37, 38]. While existing studies address CE adoption among large firms [39, 40], relatively few explore how MSMEs in developing regions incorporate the complexities of adopting circular practices. This gap underscores the need for a more focused investigation into how CE principles can be tailored to fit the realities of MSMEs in developing countries.

2.3 Barriers to adopting CE principles in MSMEs of developing countries

The transition from a conventional linear economy model to a more environmentally friendly CE model necessitates the adoption of sustainable consumption and production methods. To successfully incorporate these technologies, firms must possess adequate skills and experience. However, in emerging economies where MSMEs mostly dominate the industrial sector, they face a deficiency in such specialised knowledge and skills [3, 20, 41]. While CE is often practised in developed countries, its adoption in developing nations is still in its initial stages because of several barriers faced by the MSMEs in these countries. The specific barriers that have been found through a systematic literature review (see Table 1).

Due to apprehension about restructuring their operations, certain MSMEs may lack comprehension regarding the distinctions between CE and linear economy models, as well as the possible advantages associated with them [20, 42]. Limited knowledge resources can further exacerbate this challenge, as MSMEs often lack information in critical areas such as waste recycling techniques, circular business models, and resource efficiency strategies [43, 44]. For instance, many MSMEs are unaware of how to implement effective waste segregation practices or leverage advanced recycling technologies to reduce raw material dependency [45]. The financial limits

faced by MSMEs in developing nations exacerbate these issues, as any innovative activity to promote CE requires funding [17, 46, 47]. According to the research conducted by de la Cuesta-Gonzalez and Morales-García [48] and Nikam and Melati [44], financial institutions view the uncertainty surrounding CE practices as a key barrier to making investment decisions, which makes it difficult for MSMEs to obtain funds from traditional banks for sustainable measures and green product development [3, 49]. According to Cantú et al. [19], the absence of external assistance in funding discourages entrepreneurs from embracing CE techniques. Within competitive markets, MSMEs may encounter difficulties in distinguishing their products only based on sustainability, as they prioritise maintaining low prices, which makes them reluctant to adopt CE business strategies [36, 50–52]. The shift towards a CE necessitates a greater emphasis on optimising resource usage and procurement [53, 54]. However, recent research indicates that the successful implementation of CE in MSMEs is hampered by elements such as inadequate market mechanisms for recovery and the inefficient use of sustainable resource management methods [55, 56]. Furthermore, there is a lack of synchronised government efforts to accelerate the transition towards a CE [41, 57, 58]. Regulatory authorities rarely support recyclable solutions or industry-specific training, limiting MSMEs' adoption of CE practices [3, 59, 60].

Despite the expanding literature on CE, a considerable amount lacks robust empirical support, particularly concerning its consequences in developing countries, leading to conflicting policy recommendations. Existing research frequently generalises CE ideas, neglecting the structural, cultural, and institutional contexts of developing nations. This study differentiates itself from prior studies by concentrating on the distinct barriers MSMEs encounter in developing countries when adopting CE practices. The majority of existing studies on CE focus on its implementation in developed nations with robust infrastructures, such as the European Union or China. This study examines the adoption of CE in developing nations and offers cross-contextual insights into the influence of varying governmental and commercial settings on CE adoption in these regions. The study demonstrates how CE might assist MSMEs in developing countries in innovating despite financial and infrastructural limitations. This research presents a detailed examination of 16 specific barriers to CE adoption in MSMEs, encompassing financial, technological, administrative, and cultural barriers. Furthermore, it prioritises these barriers and seeks to elucidate the contextual interrelationships among them, in contrast to previous studies that predominantly provide generic insights.

Most previous research utilises qualitative methodologies, like case studies, interviews, or rudimentary surveys, which, although beneficial for exploratory insights, frequently lack the analytical rigour necessary to uncover intricate interdependencies across barriers. Limited research endeavours to systematically characterise these interrelationships or identify the most significant barriers. This study utilises the WINGS technique to rank these barriers and elucidate their contextual interrelationships. In contrast to conventional methodologies, WINGS is a comprehensive methodology that distinctly evaluates both the intensity of influence and the overall relevance of each barrier, providing a nuanced knowledge of the barriers faced by MSMEs. The WINGS technique has been utilised across multiple domains, such as project selection [61], cultural heritage [62], green supply chain [63], reverse logistics [64], blockchain in healthcare [65], industrial symbiosis [66], and digital twin applications in the agro-food supply chain [67]. Nonetheless, this methodology has not yet been utilised in the context of CE implementation in MSMEs in emerging economies. This work seeks to enhance WINGS by a thorough literature review, aiming to discover the relative influence and contextual connections of barriers rather than merely enumerating them. This dual-method approach improves the profundity and relevance of findings. The report provides customised policy recommendations for MSMEs, including financial incentives, infrastructural enhancement, and educational initiatives to facilitate the shift to a CE. This research provides actionable insights that address the specific needs of MSMEs, thereby bridging the gap between theory and reality in emerging economies.

A substantial amount of research on CE exists; however, no study has precisely prioritised or established the contextual interrelationships among barriers to CE adoption within MSMEs in developing economies. Consequently, it is essential not only to identify the CE barriers encountered by MSMEs in developing nations but also to ascertain whether these barriers are interrelated, specifically if the presence of one barrier influences the occurrence of another. A comprehensive understanding of each barrier and its influence on CE implementation is crucial for its effective acceptance. This study meticulously examines the interconnections among the barriers to CE in MSMEs in developing countries, with the objective of promoting its adoption through targeted policy implications.

Table 1. Barriers to CE adoption in MSMEs of developing economies

Barriers	Description	Reference
Financial constraints	It refers to the lack of sufficient financial opportunities faced by MSMEs to adopt any innovative circular models from leading financial institutions.	[44, 47, 52, 53, 55, 56, 59, 68–71]
Lack of investment support	It refers to the lack of initial investment for MSMEs to adopt circular practices due to potential uncertainties attached to such new models.	[48, 50–52, 55]
Lack of infrastructure	It refers to the poor infrastructural facilities involved in the MSMEs, which hinder their potential to adopt several advanced technologies required for circular practices.	[43, 50, 68, 72–74]
Lack of government support	It refers to the lack of sufficient governmental support for the MSMEs adopting circular practices, which demotivates them.	[3, 20, 36, 41, 44, 57, 74]
Administrative burden	It refers to the extra burden from the administration, which diverts the resources and attention of the MSMEs away from implementing circular practices.	[3, 51, 71]
Lack of regulation	It refers to a lack of regulatory pressure or incentives that may give little motivation to the MSMEs to implement circular practices.	[44, 50, 55, 59, 68, 70, 73]
Lack of technical resources	It refers to the limited access to advanced tools and techniques on the part of the MSMEs, which are essential for the adoption of successful circular principles.	[3, 20, 41, 44, 51, 52, 55, 56, 71, 72]
Lack of resource efficiency	It refers to a lack of efficiency in resource use that makes it difficult for MSMEs to secure the necessary initial investment required for adopting CE practices.	[48, 53, 56]
Lack of information	It refers to the insufficient information regarding specific benefits and strategies involved in circular practices on the part of the MSMEs.	[50, 72]
Lack of potential knowledge	It refers to the lack of sufficient knowledge regarding the circular practices, which hinders their adoption in MSMEs.	[20, 41, 43, 44]
Lack of consumer awareness	It refers to the lack of consumer awareness regarding eco-friendly products, which ultimately reduces their demand in the market and makes MSMEs less curious to adopt circular practices.	[20, 36, 41, 43, 44, 52, 55, 74, 75]
Hesitant company culture	It refers to a more rigid company culture, which makes them reluctant to innovate and shift to a more progressive circular model.	[2, 36, 74]
Lack of support from stakeholders	It refers to a lack of support from stakeholders, such as suppliers, customers, or investors, which hinders MSMEs in developing countries from adopting and sustaining CE practices.	[3, 43, 44, 52, 55, 56, 71, 74]
Existing competition	It refers to the tight competition among the MSMEs, which pressures them to gain short-term advantages over sustainable gain.	[50, 51, 72]
Lack of collaborative culture	It refers to a lack of a collaborative environment that deteriorates the participation among the MSMEs in opting for circular practices.	[20, 51, 70]
Circular risk	It refers to the potential risk associated with CE adoption, which makes MSMEs less curious about adopting sustainable practices.	[48, 71, 73]

Source: Authors' review.

3 Conceptualisation and method

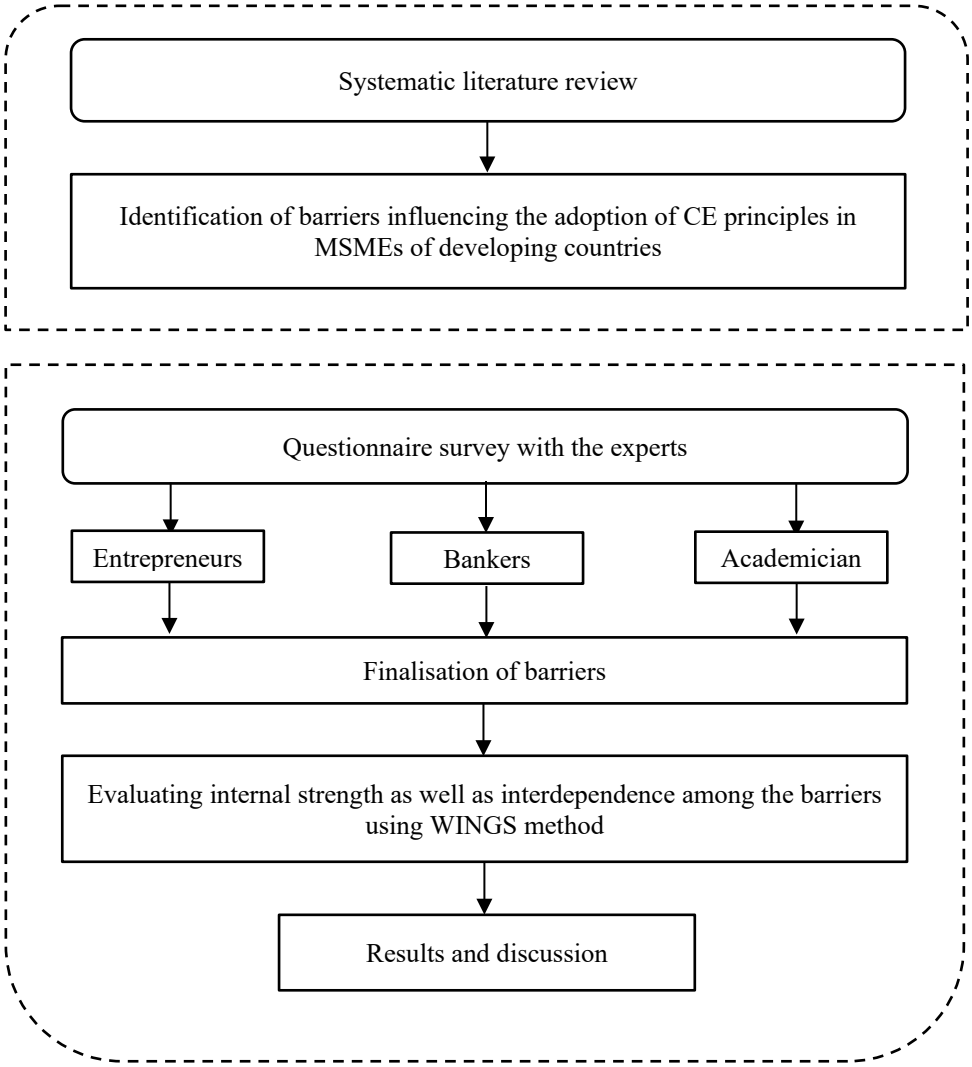
The current investigation builds directly on our previous study [22], where we identified 16 significant barriers to CE adoption in MSMEs through a systematic literature review using databases such as Scopus, Web of Science, and Google Scholar. In that initial work, specific search terms were used, including phrases like ((“Circular economy” OR “Closed loop economy” OR “Regenerative economy” OR “Material recycling” OR “Circular business economy” OR “Reuse of waste” OR “Circular consumption” OR “Circular production” OR “Circular economic cycle” OR “Circular system” OR “circularity”) AND (“MSME” OR “SME”) AND (“Enablers” OR “Facilitators” OR “Opportunities” OR “Drivers” OR “Promoters” OR “Barriers” OR “Challenges” OR “Hindrances” OR “Impediments” OR “Hurdles” OR “Roadblocks” OR “obstacles”)). However, for this study, we focused exclusively on barriers within developing economies, leaving out enablers. These 16 barriers identified in the previous study are directly carried forward into this research. Upon building on that foundation, this paper employs the WINGS methodology to analyse the intensity and overall influence of each barrier, offering a comprehensive evaluation of their interrelationships and extending insights into the barriers affecting CE adoption in MSMEs within developing economies.

The WINGS methodology, as applied in earlier studies [66, 67], was applied in this work to categorise barriers into causal and effect groups and create a structural model. This classification was based on the dual considerations of each barrier’s impact and internal strength. Both the WINGS approach and the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method were found to be highly pertinent to the current research. DEMATEL, a computational tool, employs digraphs and matrices to establish structural models, assessing the degree of influence among the examined elements. However, this method focuses solely on the intensity of influence without accounting for the inherent strength of an element. In order to overcome this limitation, the WINGS approach integrates both the intensity and strength of influence to provide a more comprehensive analysis. This integration addresses the intrinsic relationship between these two factors, which must work in tandem to accurately capture the fundamental interconnections within an integrated system. The WINGS methodology thus bridges this gap, offering a holistic framework to better understand such relationships. A visual representation of this framework is

provided in Fig. 1. However, the WINGS technique may encounter subjectivity that is inherent to human judgments and cannot be entirely eradicated. Nevertheless, the impact can be reduced by engaging numerous experts, which was the approach taken in this study.

The WINGS method has been applied in various fields, but this approach has yet to be employed in the context of CE implementation in MSMEs in emerging economies. Due to the novelty and forward-thinking nature of the circular business model, it is important to comprehend both the internal importance and intensity of the influence of the barriers. Therefore, the WINGS technique was used to examine the barriers to the CE in MSMEs in developing economies (see Table A1).

Fig 1. The proposed research framework



Source: Authors' construct.

4 Data collection and interpretation

The experts for this study were selected using a combination of purposive and snowball sampling techniques. Purposive sampling allowed us to deliberately select individuals who possessed substantial knowledge and experience with CE practices in MSMEs. Given the limited number of such experts in developing nations, snowball sampling was also employed to expand the pool by leveraging referrals from initial participants. The eligibility criteria for expert selection were clearly defined to ensure the inclusion of individuals with substantial and relevant experience. Experts were required to have a minimum of five years of professional engagement in CE-related projects, policymaking, or implementation. Academic qualifications such as a doctorate or postgraduate degree in disciplines like environmental economics, sustainable development, or industrial engineering were preferable. Furthermore, direct involvement with MSMEs or sustainability policy at either the institutional or grassroots level was also a key criterion. Thus, to expand the group of specialists, using our wide network, we made personal phone calls and sent emails to 42 experts. Among these, a total of 23 experts consented to take part in the focus group. Notably, 15 of these experts held doctorate degrees, and 7 had more than 20 years of experience in this field (see Table 2). The inclusion of a diverse group of experts, including academics, bankers and entrepreneurs, facilitated the integration of many perspectives on the CE business model. Identifying suitable experts was difficult due to the specialised focus on CE in MSMEs, particularly in developing countries. We also faced other recruitment obstacles, including time limitations, reluctance to engage, and geographic dispersion. These issues were resolved by delivering comprehensive study summaries to demonstrate the research's academic reputation, providing flexible scheduling, and ensuring anonymity.

The experts received a structured questionnaire and were subsequently asked to evaluate the impact of each barrier on the other 15 barriers using a 5-point verbal scale: 'no influence (0)', 'low influence (1)', 'medium influence (2)', 'high influence (3)', 'very high influence (4)'. They also assessed the strength of each barrier using a 5-point verbal scale: 'No strength (0)', 'low strength (1)', 'medium strength (2)', 'high strength (3)', 'very high strength (4)' as indicated in Step 3 of Table A1.

Table 2. Profile of experts and participants

Dimensions	Details	No. of experts	Dimensions	Details	No. of experts
Gender	Male	16	Profession	Academician/Researcher	21
	Female	7		Entrepreneur	1
				Banker	1
Qualifications	Postgraduate	3	Years of Experience	<5 years	8
	Doctorate	15		5 – 10 years	3
	Professional Degree	2		11 – 20 years	5
	Others	3		>20 years	7

Source: Data gathered from subject matter experts.

The data collection process was followed by a structured analytical phase. To facilitate a transparent and replicable analysis, a WINGS methodology was applied, which is a Multi-Criteria Decision-Making (MCDM) technique designed to analyse interdependencies and influence flows in complex systems. The responses from all experts were aggregated to compute the average direct strength-influence matrix (D), which captures the direct influences one barrier has on another along with the internal strength of each barrier as indicated in Appendix Table A2. The matrix was then normalised using Step 5 of Table A1, resulting in the normalised matrix (S) (see Appendix Table A3). Subsequently, Step 6 was employed to generate the overall strength-influence matrix (T), presented in Table 3, which is one of the most critical outputs as it reveals how strongly each barrier influences and is influenced by all others, providing a more holistic view of systemic relationships. In addition, the strength-influence matrix (T) was used to calculate different indicators, such as the total impact (R_i) sum of row elements representing the degree to which a barrier influences others and the total receptivity (C_i) sum of columns indicating how much a barrier is influenced by others for a specific construct. The aggregate of rows and columns is called the total engagement ($R_i + C_i$), signifying the overall involvement of a barrier in the system, while the difference between them is called the role ($R_i - C_i$) utilised to classify barriers into cause-and-effect categories within the system. Moreover, these criteria are used to rank the barriers to the adoption of CE in the MSMEs in emerging economies, as shown in Table 4.

5. Results

This section focuses on prioritising the barriers that impede the adoption of CE concepts in MSMEs in developing economies, which is our first research question ***(RQ1)***. The prioritisation is based on indicators derived using the WINGS method. These indicators—engagement score,

impact score, and role score—were chosen for their ability to capture not only the importance of individual barriers but also their interrelationships within the system. This methodological approach is grounded in prior analytical insights [66]. Table 4 presents the hierarchical arrangement of barriers according to different scores. The engagement score, derived from the combined impact and receptivity scores, indicates the overall significance of a barrier. A high engagement score suggests that the barrier plays a crucial role in the framework, both shaping and being shaped by the system. In contrast, the role score reflects a barrier's influence on other barriers. A positive role score designates a barrier as part of the cause group, those exerting influence on others, whereas a negative role score places it in the effect group, that are largely influenced by the broader system. This classification is particularly helpful in identifying leverage points for systemic interventions. As shown in Table 4, a total of eight barriers were categorised under the cause group, while another eight were assigned to the effect group.

Michnik [76] suggests that two indicators (R_i) and $(R_i + C_i)$, are suitable for ranking and yield relatively similar results. In this study, it is evident that the ranking results based on these two variables are remarkably similar. As shown in Table 4, the top five barriers to implementing CE practices in MSMEs are the lack of investment support (B7), financial constraints (B1), lack of resource efficiency (B6), lack of infrastructural facilities (B10) and lack of technological resources (B2) in terms of $(\boldsymbol{R_i + C_i})$**.** These barriers are deeply embedded within the system, exerting and receiving influence across multiple dimensions. The prominence of financial constraints is consistent with previous findings by Kafel and Nowicki [53], Virmani et al. [56], and Ezeudu et al. [59], who emphasise limited financial capacity as a pervasive challenge for CE adoption among MSMEs in developing contexts. Similarly, the critical role of lack of investment support has also been validated by Sharma et al. [52], Briguglio et al. [50], and de la Cuesta-González [48], who report that insufficient investment avenues and risk-averse financial institutions hinder circular transition efforts.

The primary barriers regarding $(\boldsymbol{R_i})$ measures a barrier's capacity to influence others, are the lack of investment support (B7), lack of infrastructural facilities (B10), financial constraints (B1), lack of potential knowledge (B13), and lack of resource efficiency (B6). Notably, our findings regarding the lack of potential knowledge are supported by Nikam and Melati [44] and Mukherjee et al. [43], both of whom identify knowledge gaps as a major bottleneck for MSMEs to internalise

and implement CE practices. Similarly, as per Briguglio et al. [50], the lack of proper resources and infrastructural facilities, especially in developing countries, also acts as a critical barrier to CE adoption by the MSME sector.

On the other hand, the top five barriers with respect to $(\boldsymbol{R_i - C_i})$ are the lack of regulation (B16), lack of administrative burden (B14), lack of support from stakeholders (B9), hesitant company culture (B4) and lack of potential knowledge (B13), revealing the strongest root causes in the system. Similarly, the identification of lack of regulation of existing administrative burden as a root cause is corroborated by Abdelmhmud et al. [68] and Madaan et al. [55], who argue that vague or absent regulatory frameworks significantly undermine MSMEs' transition to CE in developing economies.

It is worth mentioning that one barrier, i.e. lack of potential knowledge (B13), appears in the top five barriers list in both the rankings of (R_i) and $(R_i - C_i)$. This dual role implies that it is not only a significant driver of other barriers but also a foundational barrier itself, underscoring the critical need for addressing knowledge dissemination in the CE context. Conversely, although barriers such as financial constraints and lack of investment support rank high in engagement and impact, their lower role scores suggest they are more often outcomes of other systemic barriers rather than root causes (see Fig. 3). Hence, the analysis shows that while there is considerable similarity between the rankings of barriers based on impact and engagement score, there is less alignment between engagement and role indicating that the importance of certain barriers shifts depending on the aspect being evaluated.

These findings have important practical implications for policymakers and industry stakeholders. The consistent prominence of barriers such as financial constraints, lack of investment support, and limited knowledge signals key leverage points for intervention. Addressing these barriers could significantly accelerate the adoption of CE practices among MSMEs by improving access to finance, incentivising investment in circular innovations, and enhancing knowledge dissemination through targeted training and capacity-building programs. Focusing on these critical areas can create an enabling environment for a systemic transition towards circularity in developing economies.

Table 3. The total strength–influence matrix (*T*)

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
B1	**0.0054**	**0.0052**	0.0040	0.0033	0.0042	**0.0051**	**0.0053**	0.0036	0.0040	**0.0050**	0.0044	0.0041	0.0042	0.0035	0.0040	0.0038
B2	**0.0046**	**0.0053**	0.0036	0.0037	0.0035	0.0044	0.0042	0.0040	0.0035	0.0043	0.0040	0.0038	0.0037	0.0034	0.0037	0.0033
B3	0.0033	0.0033	0.0045	0.0035	0.0036	0.0042	0.0042	**0.0049**	0.0043	0.0036	0.0043	0.0036	**0.0046**	0.0036	0.0040	0.0035
B4	0.0042	**0.0048**	0.0038	0.0038	0.0034	**0.0046**	0.0044	0.0038	0.0044	0.0040	0.0040	0.0043	0.0042	0.0039	0.0035	0.0036
B5	**0.0050**	**0.0046**	0.0036	0.0033	0.0043	0.0038	**0.0051**	0.0036	0.0041	**0.0049**	0.0042	0.0039	0.0043	0.0042	0.0039	0.0043
B6	**0.0054**	**0.0051**	0.0038	0.0040	0.0038	**0.0047**	0.0044	0.0040	0.0039	0.0045	**0.0046**	0.0039	0.0042	0.0040	0.0042	0.0039
B7	**0.0058**	**0.0053**	0.0041	0.0043	0.0043	**0.0051**	**0.0047**	0.0042	**0.0046**	**0.0047**	0.0045	**0.0046**	0.0041	0.0043	0.0045	0.0035
B8	0.0038	0.0043	**0.0050**	0.0039	**0.0046**	**0.0049**	**0.0047**	0.0040	0.0041	0.0043	0.0040	0.0043	**0.0046**	0.0038	0.0041	0.0033
B9	**0.0050**	**0.0046**	0.0039	0.0045	0.0039	**0.0050**	**0.0048**	0.0043	0.0034	0.0042	0.0043	0.0044	0.0044	0.0043	0.0041	0.0030
B10	**0.0053**	**0.0049**	0.0036	0.0035	0.0040	**0.0053**	**0.0050**	0.0043	0.0043	0.0043	0.0045	0.0044	0.0042	0.0041	0.0040	0.0037
B11	0.0045	0.0044	0.0036	0.0040	0.0042	0.0045	0.0041	0.0038	0.0044	0.0041	0.0041	0.0042	0.0040	0.0035	0.0038	0.0034
B12	0.0043	0.0040	0.0036	0.0042	0.0038	0.0043	0.0043	0.0039	0.0040	0.0042	0.0042	0.0045	0.0040	0.0039	0.0043	0.0034
B13	0.0044	**0.0047**	0.0042	0.0042	0.0040	0.0045	**0.0048**	**0.0047**	0.0042	0.0041	0.0045	**0.0047**	0.0044	0.0039	0.0039	0.0032
B14	0.0044	0.0045	0.0039	0.0045	0.0041	**0.0049**	0.0045	0.0042	0.0044	0.0043	0.0038	0.0043	0.0038	0.0038	0.0041	0.0038
B15	0.0043	0.0039	0.0041	0.0035	0.0041	0.0043	0.0044	0.0038	0.0039	**0.0046**	0.0042	0.0035	0.0036	0.0038	0.0036	0.0037
B16	0.0041	0.0042	0.0043	0.0040	**0.0050**	0.0040	0.0039	0.0044	0.0038	0.0038	0.0039	0.0037	0.0040	0.0045	0.0040	0.0034

Source: Data gathered from subject matter experts. *Note:* Bold values in the table indicate relationships that exceed/equal the threshold value of 0.0046, signifying a significant relationship.

An influencing map was created to determine the contextual interrelationships among the barriers in accordance with our second research question ***(RQ2)***. The threshold value (0.0046) was determined by using the "average of total strength-influence matrix + standard deviation". If a number in Table 3 is either equal to or over this level, it indicates a significant causal link. Fig. 2 displays the visual depiction of the influence map. The lack of investment support (B7) and the lack of information (B8) are recognised to be substantial barriers that influence a wide number of other barriers. This aligns with the hierarchical order of barriers (1 and 7, respectively) based on their R_i score (see Table 4).

From the influenced map, it is evident that ***lack of investment support (B7)*** is influencing six barriers, namely financial constraints (B1), lack of technical resources (B2), lack of resource efficiency (B6), lack of support from stakeholders (B9), lack of infrastructure (B10), and lack of collaborative culture (B12). As per the existing literature, MSMEs usually struggle with a lack of funding, which makes it difficult for them to devote resources to research and development efforts to implement innovative CE practices [41, 44]. However, investors may be reluctant to support MSMEs in implementing CE practices because of perceived risks or uncertainty about the return on investment [71]. Breaking these interconnected cycles requires targeted policy interventions. One possible approach to address this issue is the provision of financial instruments and credit guarantees designed to reduce perceived risks and encourage private investment in circular initiatives.

The WINGS analysis also reveals that ***lack of information (B8)*** acts as a critical barrier, directly influencing five other barriers, including lack of consumer awareness (B3), lack of government support (B5), lack of resource efficiency (B6), lack of investment support (B7), and lack of potential knowledge (B13). This indicates that inadequate information dissemination not only limits consumer and government engagement but also hampers the efficient use of resources and access to financial and knowledge support, thereby compounding the difficulties in adopting CE practices in MSMEs [50, 72]. To address this, policymakers should consider establishing digital knowledge hubs tailored to MSMEs, which can serve as accessible platforms for sharing best practices, funding opportunities, and regulatory updates.

Our analysis also reflects an interesting observation about financial constraints (B1) and lack of technical resources (B2) as these two are the most receptive barriers, whereas their engagement

score is relatively high (ranked 2 and 5, respectively). This demonstrates that the adoption of CE practices is closely connected to the accessibility of financial resources and technological knowledge, both of which are influenced by numerous barriers within various cause groups.

Table 4. Prioritisation of barriers

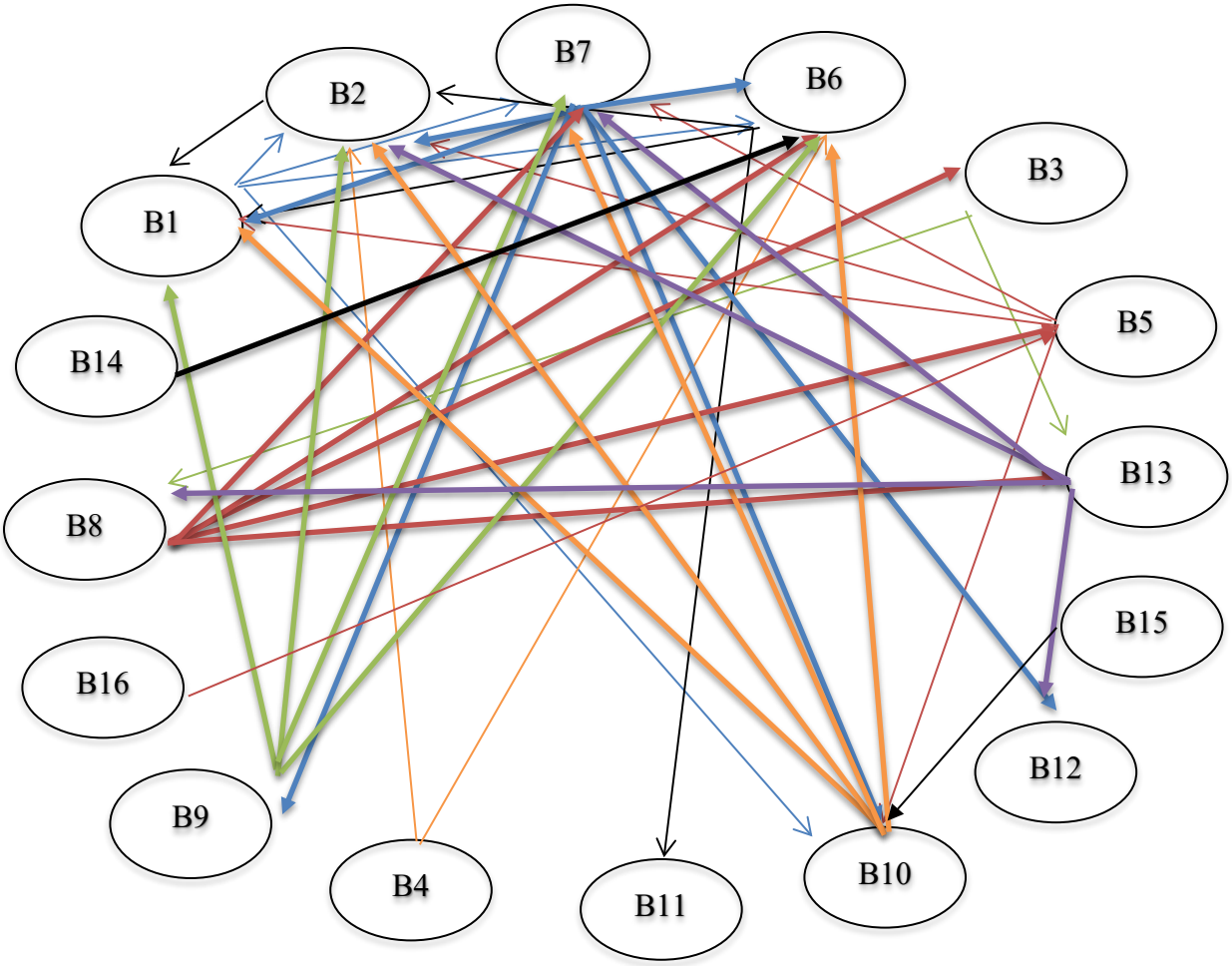
Barriers	Total Impact (R_i)	Total Receptivity (C_i)	Total Engagement ($R_i + C_i$)	Role ($R_i - C_i$)	Group
B1: Financial constraints	3	1	2	14	Effect
B2: Lack of technical resources	16	3	5	16	Effect
B3: Lack of consumer awareness	15	12	15	11	Effect
B4: Hesitant company culture	12	15	14	4	Cause
B5: Lack of government support	9	11	9	6	Cause
B6: Lack of resource efficiency	5	2	3	15	Effect
B7: Lack of investment support	1	4	1	9	Effect
B8: Lack of information	7	9	7	7	Cause
B9: Lack of support from stakeholders	6	10	8	3	Cause
B10: Lack of infrastructural facility	2	5	4	8	Cause
B11: Existing competition	13	6	10	13	Effect
B12: Lack of collaborative culture	11	8	11	12	Effect
B13: Lack of potential knowledge	4	7	6	5	Cause
B14: Administrative burden	8	14	12	2	Cause
B15: Circular risk	14	13	13	10	Effect
B16: Lack of regulation	10	16	16	1	Cause

Source: Data gathered from subject matter experts.

5 Discussion and policy implications

This research aims to propose a systematic method for prioritising the barriers to implementing CE practices in the MSMEs of emerging economies. Additionally, it seeks to analyse the interconnectedness of these barriers within their specific contexts. Existing literature primarily focuses on identifying several challenges to CE without delving into further investigation. Nevertheless, this current study advances by unravelling the connections between them. The structural model WINGS is employed for this purpose. The results obtained from the implementation of the proposed approach highlight a lack of potential knowledge (B13), lack of investment support (B7), financial constraints (B1), lack of resource efficiency (B6), and lack of infrastructural facilities (B10), which are the most significant barriers to implementing CE practices in the MSMEs of developing economies. The WINGS analysis also reveals that lack of investment support (B7) and lack of information (B8) are the two primary barriers affecting the greatest number of other barriers.

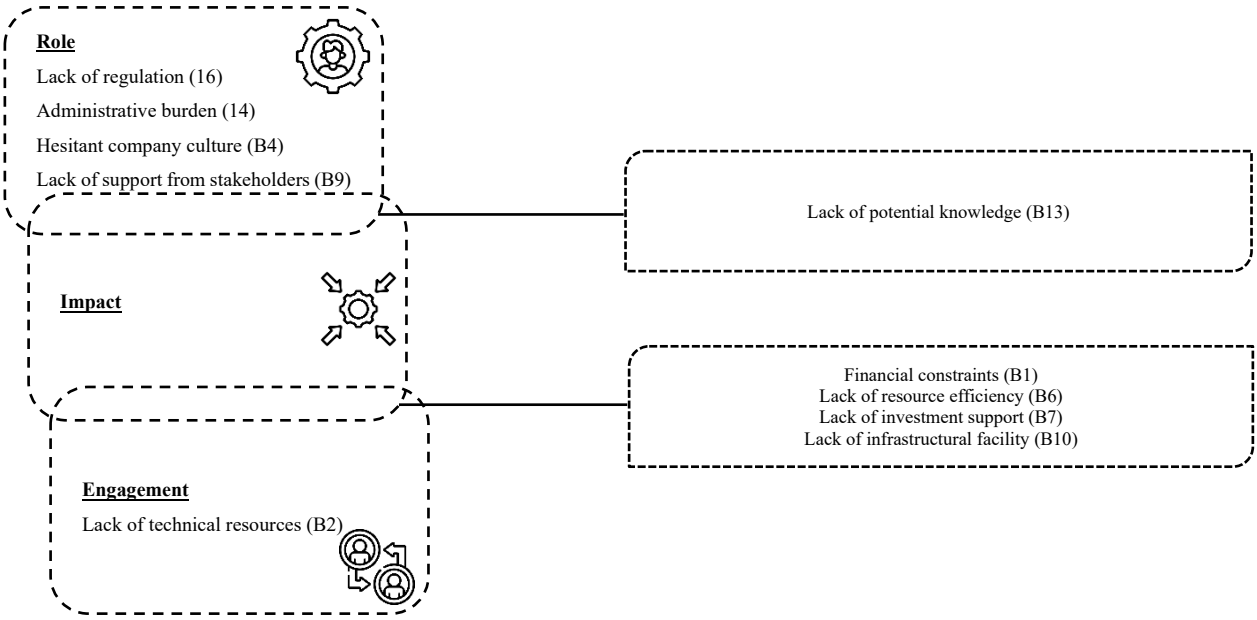
Fig 2. Influence map of CE barriers



Source: Authors' construct.

MSMEs often lack the technical expertise and awareness required to adopt CE strategies such as resource efficiency, waste reduction, and recycling [36]. This knowledge gap not only limits their understanding of the environmental and economic benefits of circular practices but also hampers innovation and the adaptation of sustainable business models [20]. Without adequate access to knowledge and external expertise, MSMEs find it challenging to integrate CE principles into their operations, which creates a significant roadblock in their sustainability journey [21]. These findings are aligned with studies such as Nikam and Melati [44] and Zuofa et al. [41], which emphasises the lack of knowledge as a core barrier to CE adoption in MSMEs of developing regions.

Fig 3. Barriers overlap across dimensions



Source: Authors' construct.

Compounding this issue is the lack of investment support. Transitioning to CE practices typically demands significant upfront investment in technology and infrastructure, which many MSMEs in developing economies cannot afford [20]. They face challenges in securing traditional financing, such as bank loans, as financial institutions in these regions frequently view CE initiatives as high-risk, discouraging them from offering capital [77]. These findings are consistent with Kuok and Promentillab [51] and Abdelmhmud et al. [68], who identified inadequate investment support as a major impediment to CE transition in MSMEs.

This financial gap makes it challenging for MSMEs to scale or even initiate CE practices. This observation also corroborates the works of Madaan et al. [55], Abdelmhmud [68], and Ezeudu [59], who identify financial constraints as persistent and systemic barriers in developing country contexts. Adding to these barriers is the lack of infrastructural facilities, which significantly hinders the implementation of CE models. Many developing economies lack the necessary infrastructure for efficient waste management, recycling, and remanufacturing, making it difficult for MSMEs to engage in CE activities [72]. Poorly developed transportation networks, energy supplies, and waste management systems, as well as a lack of digital infrastructure, limit the effectiveness of resource optimisation and collaboration efforts crucial for a CE [50]. These

significant challenges underscore the need for targeted interventions, a conclusion that aligns with the findings of other researchers.

5.1 Practical implications

The results of this study have significant practical consequences for MSMEs in emerging economies that are striving to adopt CE practices. The identification of primary barriers, including the lack of potential knowledge (B13), lack of investment support (B7), financial constraints (B1), lack of resource efficiency (B6), and lack of infrastructural facilities (B10), indicates the necessity for specific approaches to assist these enterprises in surmounting these difficulties.

Many times running with antiquated technologies and ineffective procedures, MSMEs in poor countries cause a large waste of resources [50]. Adoption of CE is essential since improving resource efficiency lowers operating costs, waste disposal costs, and dependency on expensive raw material imports. Low-cost modular composting systems, for example, enable MSMEs in food processing to turn organic waste into compost, therefore reducing fertiliser use and disposal costs [21]. Policymakers should thus set up shared resource centers with modern recycling and manufacturing technologies that MSMEs may easily access, together with offering customized training programs on effective process optimization. Too costly for individual MSMEs, these centers can house CE-enabling technology, including plastic shredders, compactors, bio-digesters, and textile recyclers. To promote involvement, local governments and development agencies should pay subsidized usage fees and cover the first set-up expenses. Drawing on technical inputs from engineering colleges or other corporate entities, public-private alliances might be established to sustain these facilities. Furthermore, cooperation with financial institutions—particularly regional banks and microfinance providers—can help to create customised green credit solutions.

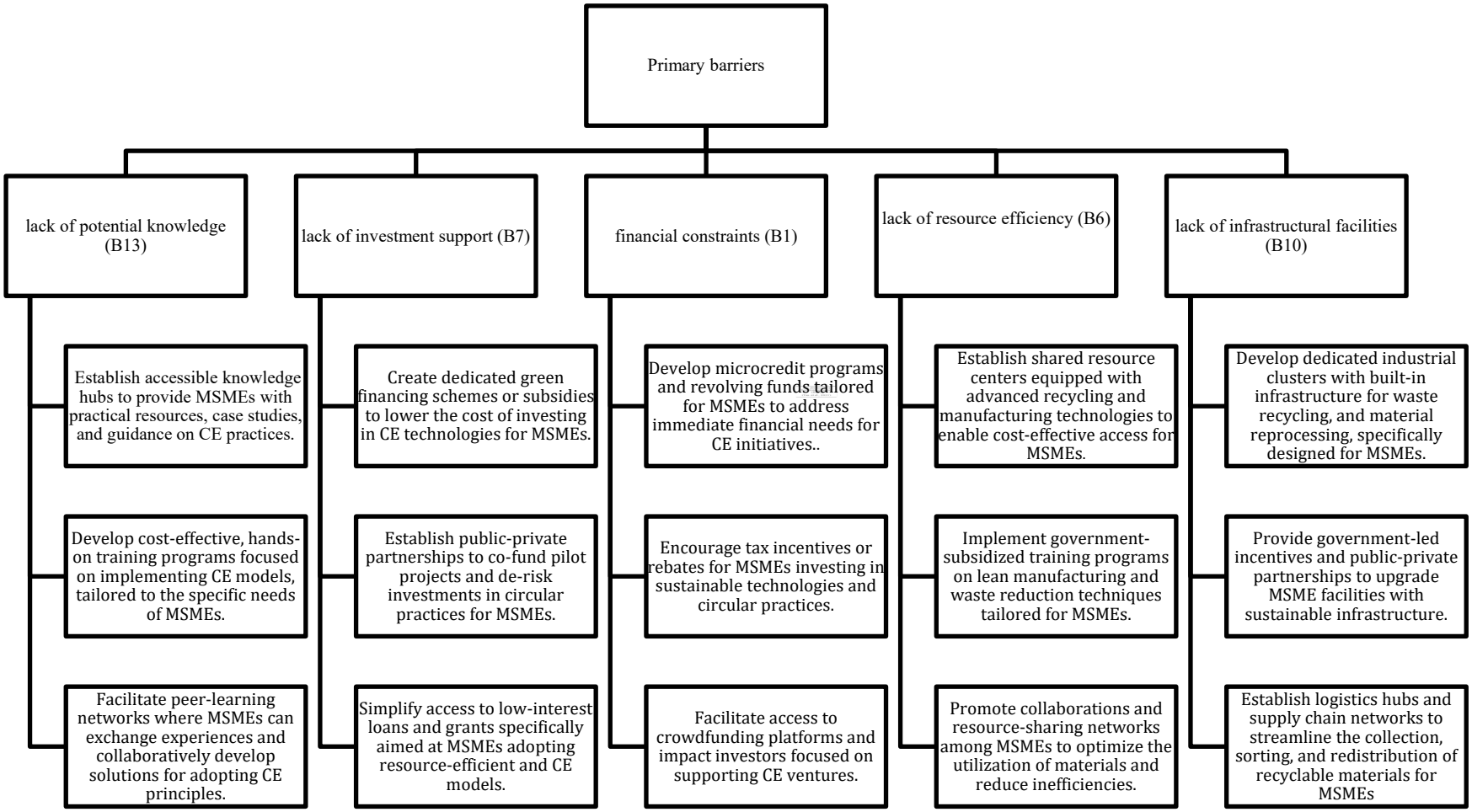
Governments, policymakers, and industry leaders should focus on establishing specialised education and training programs that emphasise awareness of CE principles to enhance the technical understanding of MSMEs. These training programs should be specifically tailored to suit the needs of MSMEs separately. For instance, micro-enterprises could benefit from short-term educational programs conducted in the local languages focused on low-cost CE solutions, while medium-sized enterprises may be equipped to undertake digital CE audits and implement Enterprise Resource Planning (ERP) systems for waste tracking. Moreover, sector-specific

interventions are needed. For example, manufacturing MSMEs could benefit from resource-efficient, cleaner production techniques and waste exchange platforms, while service-oriented MSMEs may require awareness programs on dematerialisation and digital solutions. Trading enterprises could be incentivised to adopt green logistics and eco-packaging practices. These differentiated strategies ensure the practical applicability of CE across the diverse MSME landscape.

Furthermore, establishing easily available financial structures, such as grants, tax breaks, subsidies, or loans with low interest rates, can empower small businesses to allocate funds towards essential technology and infrastructure. However, MSMEs must enhance their financial education and business approach in order to draw in investment and use innovation and technology to increase production. Enhancing the physical and digital infrastructure, including waste management systems and digital platforms for resource-sharing, will enable MSMEs to participate more effectively in CE operations. For instance, a government-supported "CE digital marketplace" could be developed, allowing MSMEs to engage in CE practices by buying, selling, or exchanging resources, services, or information. Additionally, collaboration among MSMEs, governments, and larger corporations needs to be institutionalised through formal networks and platforms. These platforms can facilitate mentorship, supply chain integration, and co-investment opportunities. Larger corporations could provide MSMEs with CE transition roadmaps, access to technology, and inclusion in green procurement programs.

Tailoring interventions to overcome these barriers might facilitate the adoption of sustainable practices by MSMEs, hence promoting economic growth and environmental sustainability in emerging economies. The decision pathways for addressing major CE barriers, specifically concerning MSMEs, are illustrated in Fig. 4.

Fig 4. Decision pathways for overcoming significant CE barriers



Source: Authors' construct.

5.2 Theoretical implications

This study contributes to the theoretical understanding of CE adoption in MSMEs by addressing a critical gap in the literature—the lack of research exploring how barriers interrelate, especially in developing economies. While previous studies have identified individual barriers, this paper goes beyond by examining their interconnections using the WINGS model. Unlike other MCDM techniques, such as Interpretative Structure Modelling (ISM), Total Interpretative Structure Modelling (TISM) solely assesses the existence of interrelationships, disregarding their intensity. Conversely, DEMATEL solely accounts for the influencing intensity of an element, disregarding its strength. In such a scenario, WINGS provides a more comprehensive analysis by considering both the intensity of influence and the internal significance of the barriers. This dual consideration offers deeper theoretical insights into how these barriers collectively impact MSMEs, presenting a more nuanced framework for understanding CE adoption in developing countries. Apart from that, this model introduces a more comprehensive lens by integrating engagement, impact, and role scores. This triangulated metric allows researchers to distinguish not just between important and influential barriers but also between root causes and resultant symptoms. Thus, the WINGS approach makes a unique theoretical contribution by enabling a systemic interpretation of CE barriers in MSMEs, particularly suited to complex institutional environments where multiple factors interact dynamically.

6 Conclusion and limitations

In the contemporary discourse surrounding economic development, there is a global effort to achieve rapid economic growth while mitigating environmental degradation. Within this context, the integration of CE practices among MSMEs is a pivotal strategy, especially for developing nations, as such adoption promotes sustainable resource utilisation and waste management while also fostering inclusive and resilient economic growth. However, there are significant barriers to CE adoption in MSMEs. This study identifies and assesses these key barriers by utilising a systematic review of existing literature—a process that builds directly on our previous work [22] to pinpoint significant barriers. These findings are further validated through a survey of experts in the field via the WINGS method. The study contributes to the CE literature in two ways: *first,* by highlighting primary barriers to CE adoption, specifically within MSMEs in developing

economies; *second,* by constructing a comprehensive structural model along with an influence map of barriers, which elucidates the cause-effect relationships among these barriers. The primary hurdles to the adoption of CE in the context of MSMEs are identified as the lack of investment support (B7), financial constraints (B1), lack of resource efficiency (B6), lack of infrastructure (B10) and lack of potential knowledge (B13) in response to **RQ1**. This study significantly advances the understanding of CE adoption in MSMEs by not only listing barriers but also exploring how they interconnect in response to **RQ2**. For instance, lack of investment support (B7) and lack of information (B8) are identified as the most influential barriers, affecting six and five other barriers, respectively. This nuanced structural insight enables policymakers and practitioners to target root causes rather than symptoms, making interventions more effective and resource-efficient.

Apart from that, the implications of the study for developing economies are particularly profound. Since MSMEs often operate with limited financial and technical capacity, targeting high-leverage barriers (like B7 and B8) could unlock broader systemic improvements. Government agencies, industry associations, and international donors can use these findings to prioritise resource allocation, infrastructure development, and capacity-building initiatives.

In comparison to previous studies, this research extends the CE literature by providing an analytical framework that integrates barrier interdependencies, which were previously underexplored. While earlier works tended to focus on isolated challenges or enablers, this study offers a dynamic, systems-level understanding essential for effective CE transition planning in MSMEs.

Nevertheless, this study is not without limitations. *First,* the WINGS technique relies on expert judgment, which introduces subjectivity. Though care was taken to ensure a diverse and credible panel of experts, bias in expert selection and their interpretations cannot be ruled out. *Second,* there are potential ethical concerns, such as maintaining the confidentiality of expert responses and ensuring that no individual's input disproportionately influences the outcome. These were mitigated through anonymised inputs and equal-weight assignments, but future studies could adopt mixed-method approaches for triangulation. *Third,* the generalizability of findings is constrained—the focus on MSMEs in developing economies means that the results may not directly apply to larger firms or to contexts in developed economies, where institutional

frameworks and resource access differ considerably. However, these limitations do not compromise the authenticity or practical relevance of the study's findings. The methodological rigour, transparency in expert selection, and contextual specificity ensure that the insights derived are both credible and valuable for policymakers and stakeholders working with MSMEs in similar developmental settings.

Hence, future research should concentrate on three key areas to deepen and broaden the understanding of CE adoption in MSMEs. *First,* there is a need for empirical validation of the proposed structural study using large-scale datasets, possibly through some empirical analysis, to substantiate the influence pathways identified in this study. *Second,* future studies should aim to develop an integrated framework that connects CE barriers, enablers, and performance metrics within MSMEs, thereby offering a comprehensive and systems-oriented perspective on the CE transition. *Third,* it is essential to design and test targeted intervention strategies, particularly those addressing the most influential barriers—such as lack of investment support (B7), financial constraints (B1), lack of resource efficiency (B6), lack of infrastructure (B10), and lack of potential knowledge (B13)—to assess their practical impact on enhancing CE adoption and improving the overall performance of MSMEs.

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Appendix

Table A1. Steps of the WINGS methodology

Steps	Description
Step 1	Identification of barriers hindering the implementation of CE concepts in MSMEs in developing countries. This will be achieved through a comprehensive analysis of existing literature and gathering insights from experts in the field.
Step 2	Determination of the contextual causal relationship between the barriers. The assessment of interdependencies is conducted through the analysis of a causal influence map, as described by Michnik in 2013.
Step 3	Assessment of strength and intensity of influence: Linguistic expressions [No (N) - 0; Very low (VL) - 1; Low (L) - 2; High (H) - 3; Very high (VH) - 4] are employed to ascertain the strength of constructs and their intensity of impact on other constructs.
Step 4	Formulation of an "average direct strength – influence matrix (D)", in which numbers assessed in step 2 are inserted, where the dimension of each matrix is equal to the number of elements (n), with elements represented as d_{ij}. Values indicating the strength of components are placed on the main diagonal, while values indicating influences are placed in positions where $i \neq j$. d_{ij} represents the impact of component i on component j. Subsequently, the opinions of experts are calculated by taking the average. The generated matrix is subsequently used in the next stage for normalisation.
Step 5	Normalisation of an "average direct strength – influence matrix (D)" using the following: $S = \frac{1}{h}P$ where h is the calibrating factor defined as follows: $h = \sum_{i=1}^{n}\sum_{j=1}^{n} d_{ij}$ and s denotes the normalised matrix.
Step 6	Evaluation of the "total strength – influence matrix (T)" using the following equation: $T = S(I - S)^{-1}$ where T presents an identity matrix having a dimension equal to the number of constructs.
Step 7	Calculation of several indicators: The total impact (R_i) refers to the sum of all elements in a row of the total strength-influence matrix (T), whereas the total receptivity (C_i) refers to the sum of all elements in a column of the matrix. Subsequently, the ranking of the construct is carried out using the indicators R_i C_i, $(R_i + C_i)$ and $(R_i - C_i)$ Here, $(R_i + C_i)$ and $(R_i - C_i)$ are known as total engagement and role, respectively.

Source: Authors' construct.

Table A2. Average direct strength-influence matrix (D)

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
B1	2.6875	2.7500	2.2500	1.8125	2.1875	2.8125	2.8125	1.8750	2.2500	2.6250	2.2000	2.2500	2.3125	1.8125	2.3125	2.1250
B2	2.2500	2.8750	2.0000	2.0000	1.8750	2.2857	2.2500	2.0000	1.8750	2.1875	2.0625	2.1875	1.8750	1.9375	2.1875	1.9375
B3	1.8125	1.8750	2.5000	1.7500	1.8125	2.0625	2.0000	2.4375	2.2000	1.8750	2.2667	1.8000	2.2667	2.0000	2.3125	1.8750
B4	2.0000	2.4667	1.6875	2.1250	1.7500	2.3125	2.2000	1.6875	2.0000	1.9375	1.9375	2.0667	2.1875	1.8750	2.0000	1.8750
B5	2.5625	2.4375	1.5625	1.6250	2.2500	1.8750	2.5625	1.4375	2.0000	2.6875	2.1250	2.0000	2.1333	2.1250	2.1875	2.2667
B6	2.7500	2.5625	2.0625	2.0000	1.9375	2.5000	2.1875	1.9375	1.9333	2.3750	2.4375	1.9375	2.1250	2.3125	2.5000	2.1875

B7	2.9375	2.6875	2.1875	2.0625	2.1250	2.6250	2.4375	2.1250	2.3125	2.5625	2.4667	2.4375	2.1875	2.2667	2.5625	1.8750
B8	1.8750	2.1250	2.5000	1.8750	2.3125	2.3125	2.4375	2.2667	2.1875	2.4375	2.0625	2.3125	2.3125	2.1250	2.3750	1.8750
B9	2.5000	2.3125	2.0000	2.2500	2.0625	2.5000	2.3125	2.2000	1.7333	2.2500	2.3125	2.3750	2.4375	2.3750	2.1875	1.5625
B10	2.5000	2.6250	2.1250	1.8750	2.0000	2.6875	2.3750	2.2500	2.1333	2.2500	2.5000	2.4375	2.3750	2.2500	2.3333	2.0625
B11	2.2500	2.1875	1.8125	2.0625	2.3125	2.3750	2.0000	1.9375	2.2500	2.1875	2.1250	2.1250	2.0625	2.0000	2.2500	1.8125
B12	2.2500	2.0000	1.8125	2.0667	1.9375	2.3125	2.1875	2.0000	2.0625	2.1875	2.1875	2.5000	2.1250	2.0000	2.3750	1.8125
B13	2.4375	2.5000	2.3125	2.2500	2.0625	2.3125	2.5000	2.3750	2.2500	2.1875	2.4375	2.5000	2.5000	2.0625	2.2500	1.6875
B14	2.1875	2.1875	2.0000	2.3125	2.0625	2.6250	2.1250	2.0000	2.2500	2.2500	2.0000	2.2500	2.0625	2.0625	2.3125	2.0625
B15	2.1875	2.0000	2.0625	1.8125	2.1250	2.2500	2.1250	1.8750	1.9375	2.3750	2.0000	1.7500	1.8125	2.0000	2.0000	1.8750
B16	2.0000	2.2500	2.0000	1.9375	2.5000	2.1250	1.9375	2.1875	1.7500	1.9375	2.0000	1.8667	1.9375	2.3125	2.0625	2.0000

Source: Data collected through consultation with subject matter experts.

Table A3 Normalised Matrix (*S*)

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
B1	0.0048	0.0050	0.0041	0.0033	0.0039	0.0051	0.0051	0.0034	0.0041	0.0047	0.0040	0.0041	0.0042	0.0033	0.0042	0.0038
B2	0.0041	0.0052	0.0036	0.0036	0.0034	0.0041	0.0041	0.0036	0.0034	0.0039	0.0037	0.0039	0.0034	0.0035	0.0039	0.0035
B3	0.0033	0.0034	0.0045	0.0032	0.0033	0.0037	0.0036	0.0044	0.0040	0.0034	0.0041	0.0032	0.0041	0.0036	0.0042	0.0034
B4	0.0036	0.0044	0.0030	0.0038	0.0032	0.0042	0.0040	0.0030	0.0036	0.0035	0.0035	0.0037	0.0039	0.0034	0.0036	0.0034
B5	0.0046	0.0044	0.0028	0.0029	0.0041	0.0034	0.0046	0.0026	0.0036	0.0048	0.0038	0.0036	0.0038	0.0038	0.0039	0.0041
B6	0.0050	0.0046	0.0037	0.0036	0.0035	0.0045	0.0039	0.0035	0.0035	0.0043	0.0044	0.0035	0.0038	0.0042	0.0045	0.0039
B7	0.0053	0.0048	0.0039	0.0037	0.0038	0.0047	0.0044	0.0038	0.0042	0.0046	0.0044	0.0044	0.0039	0.0041	0.0046	0.0034
B8	0.0034	0.0038	0.0045	0.0034	0.0042	0.0042	0.0044	0.0041	0.0039	0.0044	0.0037	0.0042	0.0042	0.0038	0.0043	0.0034
B9	0.0045	0.0042	0.0036	0.0041	0.0037	0.0045	0.0042	0.0040	0.0031	0.0041	0.0042	0.0043	0.0044	0.0043	0.0039	0.0028
B10	0.0045	0.0047	0.0038	0.0034	0.0036	0.0048	0.0043	0.0041	0.0038	0.0041	0.0045	0.0044	0.0043	0.0041	0.0042	0.0037
B11	0.0041	0.0039	0.0033	0.0037	0.0042	0.0043	0.0036	0.0035	0.0041	0.0039	0.0038	0.0038	0.0037	0.0036	0.0041	0.0033
B12	0.0041	0.0036	0.0033	0.0037	0.0035	0.0042	0.0039	0.0036	0.0037	0.0039	0.0039	0.0045	0.0038	0.0036	0.0043	0.0033
B13	0.0044	0.0045	0.0042	0.0041	0.0037	0.0042	0.0045	0.0043	0.0041	0.0039	0.0044	0.0045	0.0045	0.0037	0.0041	0.0030
B14	0.0039	0.0039	0.0036	0.0042	0.0037	0.0047	0.0038	0.0036	0.0041	0.0041	0.0036	0.0041	0.0037	0.0037	0.0042	0.0037
B15	0.0039	0.0036	0.0037	0.0033	0.0038	0.0041	0.0038	0.0034	0.0035	0.0043	0.0036	0.0032	0.0033	0.0036	0.0036	0.0034
B16	0.0036	0.0041	0.0036	0.0035	0.0045	0.0038	0.0035	0.0039	0.0032	0.0035	0.0036	0.0034	0.0035	0.0042	0.0037	0.0036

Source: Data collected through consultation with subject matter experts.