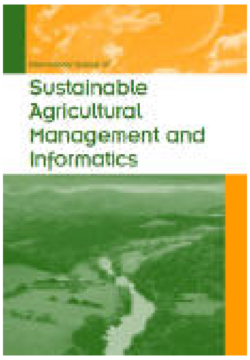

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Circular economy! Sustainable growth and achieving zero net emissions - a way ahead for building sustainable tomorrow by optimising consumption

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Circular economy! Sustainable growth and achieving zero net emissions – a way ahead for building sustainable tomorrow by optimising consumption

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Abstract: The concept of a circular economy has received an increasing amount of focus in recent years due to its potential as a means to achieve long-term economic sustainability. The current study applies the interpretive structural modelling (ISM) methodology to investigate the complex relationships between a total of 16 key variables from the literature that affect circular economy efforts. The findings imply that initiatives to advance technological know-how, awareness, resource sharing, recycling and reuse, and reverse logistics may have a substantial influence on the circular economy. As organisations seek to enhance their sustainability efforts, these insights can guide decision-makers in formulating effective strategies that harness technological advancements, optimise logistics operations, and raise awareness to foster a circular economy that benefits both the environment and society. This research based on ISM theory adds clarity on what helps spread the concept of a circular economy. It offers significant fresh insights for marketers and policy-makers.

Keywords: circular economy; circular infrastructure; zero carbon emission; product utility; resources optimisation; frugal innovation.

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1 Introduction

The concept of the circular economy has gained significant traction as a sustainable approach to economic growth and resource management as the linear model of production and consumption, based on extracting, making, using, and disposing of resources, has been dominant for decades (Tubiello et al., 2021; Kalogiannidis and Chatzitheodoridis, 2023). However, this model is reaching its physical and ecological limits, as it generates significant negative impacts on the environment and society (Geissdoerfer et al., 2017). The global material footprint is expected to reach 190 billion tonnes by 2060, more than double the current level (Long, 2021). This would result in increased greenhouse gas emissions, biodiversity loss, water scarcity, and waste generation (Singh and Singh, 2017; Vlachoudi et al., 2023).

The current linear economy problem is that it promotes a 'take-make-dispose' paradigm of consumption, whereby raw materials are acquired, changed into goods, consumed, and discarded, all of which contributes to a rise in material waste (Papathanasiou et al., 2021; Rashid and Malik, 2023; Papadopoulou et al., 2023). The linear system places its emphasis on the generation and commercialisation of a substantial quantity of products, with the primary objective of value creation being the optimisation of production output (Bianchi and Cordella, 2023; Hien and Chi, 2023). However, the utilisation of the linear model in various industries has given rise to a multitude of sustainability difficulties and environmental issues (Millar et al., 2019). A new paradigm called the circular economy is taking shape in response to these difficulties (Amaral and Berssaneti, 2023). This framework is based on three principles i.e., design: eliminate waste and pollution and keep products and materials in use and regenerate natural systems (Bressanelli et al., 2022).

Resource depletion is an important risk associated with the linear economy (Stahel, 2016). The extraction of scarce resources in order to satisfy the escalating demand for various products imposes a significant burden on both natural resources and ecosystems. This wasteful practice consequently contributes to the exacerbation of pollution levels and the degradation of the environment (Jain et al., 2023; Papadopoulou et al., 2023). In underdeveloped nations, the circular economy is still in its infancy since producers and consumers are still accustomed to the linear consumption paradigm (Muhamadi and Boz, 2022). Many nations and organisations feel the same urgency in switching to a sustainable path without delaying. In order to achieve sustainable economic growth, environmental preservation, and social inclusion, emerging nations must strongly advocate for the adoption and application of the circular economy. A circular economy goes 'beyond waste management and recycling', and the public needs to be aware of this.

The circular economy provides a framework for system-level responses to environmental and consumption-related issues (Geissdoerfer et al., 2017) and encourages environmental preservation by lowering waste and greenhouse gas emissions, systematising recycling, and outlawing intentional obsolescence (Morseletto, 2020). The current lifestyle generates a lot of waste and consumes a lot of resources (Pieroni et al., 2019; Gupta and Jain, 2020). The circular economy offers a framework for system-level responses to environmental and consumption-related issues (Geissdoerfer et al., 2017) and promotes environmental preservation by lowering waste and greenhouse gas emissions, systematising recycling, and outlawing intentional obsolescence (Morseletto, 2020). Relatively little research has been done on the circular economy, despite its critical importance (Gupta et al., 2020; Coderoni and Perito, 2020; Camacho-Otero et al., 2020; Georgantzis Garcia et al., 2021; Corvellec et al., 2022). The way we live now uses a lot of resources and produces a lot of garbage (Pieroni et al., 2019). The current study is motivated to bridge the aforementioned gap through this research. Therefore, the goal of the current study is to identify the circular economy's drivers and uncover their connections. By identifying the most significant circular economy factors that would encourage circular business practices, the current study fills the aforementioned research gap.

The study's results will also be used by policymakers to develop plans for product recycling, trash reduction, and the promotion of the idea that waste can be used as an input. These actions will improve the environment, spur innovation, and support balanced economic growth. The layout of the paper is as follow: the first chapter gives overview of circular economy, its need and its importance. The second chapter is about literature of all relevant variables driving circular economy followed by methodology and analysis. The last three section brief us about results and discussions, theoretical and managerial implications and future directions.

2 Literature review

A new paradigm for consumption and production that guarantees long-term, sustainable growth is the circular economy (Nikolaou and Tsagarakis, 2021). Because of more intelligent and effective resource use, future generations will be able to live in comfort on a healthy world with a strong and sustainable economy. By 2030, the circular economy is projected to be valued \$4.5 trillion worldwide. A sustainable development strategy to solve the urgent problems of depleting resources and deteriorating the environment is the circular economy (Sharma et al., 2022). Based on extensive literature review, the following drivers of circular economic practices have been identified.

2.1 Regulation policies

The scientific literature emphasises the importance of regulation and policies in promoting the circular economy (Kazancoglu et al., 2020). The primary objective of these policies is to disassociate economic growth from adverse environmental consequences and foster the conservation and enhancement of materials to ensure the continued utilisation of durable goods and services (Baldassarre and Calabretta, 2023). Furthermore, the scientific literature highlights the role of government regulations and policies in promoting circular infrastructure (Wasserbaur et al., 2022). In general, regulations and policies establish a structural framework and offer incentives to encourage businesses to embrace circular practices (Hina et al., 2022). Various measures can be implemented, including greater responsibility for producers, eco-design requirements, waste disposal regulations, and incentives for reuse and recycling. These policies establish a conducive atmosphere for the flourishing of circular business models and promote the integration of sustainable practices across the entire value chain. Nevertheless, it is imperative to acknowledge and confront the various challenges and limitations that exist.

2.2 Frugal innovation

Frugal innovation and the circular economy share common goals of sustainability and resource efficiency (Le Bas, 2016). Frugal innovation uses fewer resources; therefore, it is more reasonably priced and widely available than conventional innovations. It is frequently linked to ecological and social sustainability. Circular economy and frugal innovation share a conceptual nexus (Ezeudu et al., 2022). A structured scientific review of antecedent's links frugal innovation closely with concepts like 'reverse innovation', 'sustainability', 'circular economy', 'digital effectuation' and offers insights for policymakers and practitioners to understand the antecedents of frugal innovation (Jaiswal et al., 2022). The literature review found that frugal innovation can drive the adoption of circular business models by promoting the design of products for durability, reparability, and recyclability (Zupancic, 2023). By developing affordable and sustainable solutions, frugal innovation contributes to waste reduction, product longevity, hence pushing the adoption of circularity.

2.3 Resource optimisation

The circular economy and efficient use of resources go hand in hand. The goal of a circular economy is to reduce waste and pollution at every stage of the material life cycle, from mining and manufacturing to retail and consumption (Kumar et al., 2021). Reducing waste and pollution, extending the lifespan of products and materials, and revitalising ecosystems are the three pillars upon which the circular economy rests (Kumar et al., 2021). Companies can cut down on the number of raw materials by adopting circular economy principles (Velenturf and Purnell, 2021). Businesses can, for instance, adopt circular business models that prioritise waste reduction and resource efficiency by paying close attention to product design, material selection, and end-of-life management

(Cheshire, 2019). Closed-loop systems that encourage resource utilisation and waste reduction can be created when businesses collaborate with other value-chain stakeholders (Negrete-Cardoso et al., 2022). Therefore, businesses must adopt circular economy practices if they are to optimise their use of resources, increase their sustainability performance, and ultimately help create a more sustainable future.

2.4 Awareness

Awareness and education are essential for the transition to a circular economy (van Langen et al., 2021). The scientific community, policymakers, and businesses must be equipped with appropriate thinking and concepts to understand and support the transition to a circular economy (Alhawari et al., 2021). Furthermore, a systematic literature review sought to map out the key topics interrelated with innovation and the circular economy from a company perspective (Suchek et al., 2021). The review found that awareness and education are essential for the adoption of circular practices. Promoting awareness and knowledge about the circular economy and its potential benefits, will help individuals and organisations to make informed choices and actively participate in the circular economy ecosystem. Educating people about recycling, reuse, minimising energy consumption, e-waste and waste reduction will help industry moving towards circular economy (Patwa et al., 2021).

2.5 Product utility

Product utility refers to the usefulness of a product for a specific purpose. It is a critical factor in determining the value of a product and its potential for reuse or recycling (Mulhall et al., 2022). The circular economy aims to keep products, components, and materials at their highest utility and value at all times (Mulhall et al., 2022). Therefore, product utility is a crucial variable for the circular economy, as it determines the potential for a product to be reused or recycled. Product design and business model strategies are essential for a circular economy (Alhawari et al., 2021). They proposed a framework for designing products and business models that promote the circular economy. The framework includes strategies such as designing for durability, designing for disassembly, and designing for reuse. These strategies aim to increase the utility of products and promote their reuse or recycling (Moraga et al., 2019; Singh et al., 2022).

2.6 Incentives

Incentives play a crucial role in promoting the circular economy (Tukker, 2015). Incentives aim at addressing market failures that prevent or delay the transition towards circular products, services, and solutions (De Jesus et al., 2018). Several types of incentives can be used to promote the circular economy, including financial incentives, such as subsidies and tax breaks, and non-financial incentives, such as regulations and standards. Financial incentives can create value, de-risk investments, and improve the competitiveness of value chains that bring net environmental benefits when compared with linear economies (Narin and Lazaridis, 2021). Non-financial incentives can also stimulate innovation and incentivise circular economy practices.

2.7 Sharing of resources

Resource sharing pushes circular infrastructure surfacing and sharing unused assets and resources between and within businesses and institutions, the value of the items is maximised, and the need for new resources is reduced (Preston, 2012; Muhamadi and Boz, 2022). Sharing resources, such as energy, water, and materials reduce waste and increase efficiency, leading to cost savings and environmental benefits (Horbach et al., 2012). Furthermore, resource sharing also enables the development of new business models, such as product-as-a-service, which promotes circularity by incentivising the design of durable and repairable products (Velenturf and Purnell, 2021).

2.8 Re-cycling

Recycling is the practice of turning trash into useful materials. The circular economy aims to keep products, components, and materials circulating in the economy through strategies such as recycling and reusing (Stahel, 2016). These practices contribute to reducing waste, conserving resources, reduction of greenhouse emissions, minimising the environmental impact of production and consumption resulting to a more circular infrastructure (Arfaoui et al., 2023). In addition to environmental benefits, recycling and re-usage also have economic advantages. The recycling industry can create jobs and generate economic value by transforming waste materials into valuable resource (Kumar et al., 2023). By promoting recycling and re-usage, businesses can tap into new market opportunities and contribute to the growth of a circular economy.

2.9 Technological competence

Utilising the most recent technical advancements is necessary for the operations that make economic model feasible to be both efficient and cost-effective. The attainment of technological competence has the potential to facilitate the creation of novel solutions that foster circularity and enhance resource efficiency (Chauhan et al., 2022). Technology innovation will result in proper process optimisation, boosting efficiency, and, most importantly, attaining improvements in reuse and repair, as well as in remanufacturing and waste management (Glavič and Lukman, 2007). The circular economy has the potential to capitalise on emerging digital technologies, such as big data, artificial intelligence (AI), blockchain, and the internet of things (IoT) (Chauhan et al., 2022). The contribution of technological competence to waste reduction, product longevity, and material reuse can be realised through the development of innovative and sustainable solutions (Arfaoui et al., 2023).

2.10 Reverse logistics

In the circular economy, reverse logistics refers to the process of gathering and aggregating items, components, or materials after the end of their useful lives for reuse, recycling, and returns (Guarnieri et al., 2020). Reverse logistics plays a crucial role in this system by enabling the recovery and reuse of products and materials that would otherwise be discarded (Patwa et al., 2021). The implementation of reverse logistics practices has been observed to foster a stronger bond between consumers and producers, primarily through the closure of the product life cycle. The use of innovative tools (robots, autonomous bikes) in reverse logistics increases the rate at which used products are returned, thereby enhancing recycling. Technological advancements in reverse logistics assist in the development of circular product designs. The combination of reverse flow with forward flow consolidates the high volume of products, thereby reducing waste (Butt et al., 2023).

2.11 Price reduction

Implementing circular economy practices result in considerable cost reductions for companies, which serve as a major incentive for doing the same (Di Stefano et al., 2023; Awan and Sroufe, 2022). Further by limiting material costs and price volatility, decreasing reliance on imports, and decreasing demand for and reliance on virgin (rare earth elements) materials, cost and price reductions contributes to a circular infrastructure. The model of circular business aims to alter the existing pattern of product and material movement within the economy, with the ultimate goal of mitigating the negative environmental consequences (Darmandieu et al., 2022). Hence, the implementation of pricing or cost reduction strategies facilitates the adoption of a circular business model and associated practices within the business.

2.12 Societal pressure

Peer pressure shapes social norms and influences individuals to engage in recycling and other sustainable activities (Lee, 2014). When people and businesses see and are affected by the efforts of their contemporaries, their propensity to engage in circular economy activities increases (Zisopoulos et al., 2023). Individuals and organisations are more likely to engage in circular economy activities if they observe and are influenced by their peers (Milios, 2017). The impetus exerted by consumers, communities, and various stakeholders can compel businesses to accord precedence to sustainability and circularity within their operational frameworks (Arruda et al., 2021). The pressure mentioned manifests through various means, including the demand from consumers for sustainable products, the implementation of public awareness campaigns, and the active promotion of circular economy policies and regulations (Galvão et al., 2018).

2.13 Circular infrastructure

Circular infrastructure is viewed as a comprehensive network of infrastructure that has been intentionally planned, constructed, and managed to optimise the utilisation of resources, minimise the generation of waste, and foster a circular economy (Superti et al., 2021). It holds the potential to foster the advancement of a sustainable and circular economy by means of the reduction of avoidable waste and pollution through the meticulous utilisation and reutilisation of pre-existing materials (Heras-Saizarbitoria et al., 2023). It also facilitates the emergence of novel business models, such as the product-as-a-service model (Yang et al., 2023), which effectively fosters circularity by providing incentives for the creation of long-lasting and easily repairable products (Moraga et al., 2019).

Table 1 Description of variables

Factors	*Description*	*Sources*
Regulation (C1)	The regulations and incentives that support the transition to a circular economy at different levels of governance, such as taxes, subsidies, standards, bans or targets.	Kulakovskaya et al. (2023), Wasserbaur et al. (2022), Hina et al. (2022), and Baldassarre and Calabretta (2023)
Effective waste management (C2)	Effective waste management is critical for the overall effectiveness of the circular economy since how we handle waste is one of the most significant issues with our current economic model.	González-Sánchez et al. (2023)
Resources optimisation (C3)	Less is more in a resource-efficient firm since raw resources are used sparingly and sustainably. The circular economy prioritises reusing materials and reintroducing them into the value chain as opposed to disposing of them as waste.	Velenturf and Purnell (2021), Cheshire (2019), and Negrete-Cardoso et al. (2022)
Awareness (C4)	The circular economy will only become a reality if consumers' future behaviour is influenced by the knowledge they have. Consumer awareness of the circular economy is expanding, and they have a generally favorable opinion.	Arruda et al. (2021), Alhawari et al. (2021), Patwa et al. (2021), and Suchek et al. (2021)
Product utility (C5)	Modular design, design for disassembly, design for durability, design for remanufacturing, design for recycling, and design for circular business models are some of the ways in which better product design leads to circularity.	Mulhall et al. (2022), and Moraga et al. (2019)
Incentives (C6)	Incentives have the power to generate value, reduce investment risk, and boost the competitiveness of value chains. They also benefit society and the economy. Incentives (such as those for coming up with new ideas for cleaner production, repairing, or remodeling), low-interest loans, subsidy policies, tax breaks, and return policies are driving forces behind circular economy projects.	Tukker (2015), Dapp (2018) and Narin and Lazaridis (2021)
Sharing of resources (C7)	By surfacing and sharing unused assets and resources between and within businesses and institutions, the value of the items is maximised, and the need for new resources is reduced.	Velenturf and Purnell (2021)
Recycling and reuse (C8)	In order to create new items, the process of recycling requires the recovery of elements from already existing ones. This method can help advance circularity by encouraging less waste and better utilisation of available resources.	Arfaoui et al. (2023), and Kumar et al. (2023)
Reverse logistics (C9)	Businesses must dispose of waste in an environmentally responsible way in order to encourage a circular economy and lower waste generation. Therefore, effective reverse logistics can assist with the most effective waste disposal, recycling, and reuse.	Guarnieri et al. (2020), Patwa et al. (2021), and Butt et al. (2023)

Table 1 Description of variables (continued)

Factors	*Description*	*Sources*
Technological competence (C10)	The circular economy has the potential to capitalise on emerging digital technologies, such as big data, AI, blockchain, and the IoT. These technologies can enable the development of innovative circular business models, facilitate the tracking and tracing of materials and products, and promote resource efficiency and waste reduction.	Chauhan et al. (2022), Glavič and Lukman (2007), and Arfaoui et al. (2023)
Price reduction (C11)	Cost and price reduction contributes to a circular infrastructure by limiting material costs and price volatility, reducing dependency on imports, and reducing demand and reliance of virgin (rare earth elements) materials.	Di Stefano et al. (2023) and Awan and Sroufe (2022)
Circular infrastructure (C12)	By enabling the development of closed-loop systems, promoting resource efficiency, and reducing waste generation, logistics constraints, circular infrastructure can contribute to the transition towards a more sustainable and circular future.	Superti et al. (2021), Heras-Saizarbitoria et al. (2023), Moraga et al. (2019), and Yang et al. (2023)
Local production (C13)	Local production enables the development of closed-loop systems that minimise waste and maximise resource efficiency. By embracing local production, businesses can optimise the use of resources, reduce waste, and promote circularity.	Arsova et al. (2022), and Arruda et al. (2021)
Societal pressure (C14)	Peer pressure mentions that it shapes social norms and influence individuals to engage in recycling and sustainable activities. By observing and being influenced by their peers, individuals and organisations may be more inclined to engage in circular economy activities.	Zisopoulos et al. (2023), Milios (2017), and Lee (2014)
Frugal innovation (C15)	Frugal innovation promotes the development of affordable and sustainable solutions, which aligns with the principles of the circular economy. Frugal innovation works to cut waste, lengthen product lifecycles, and encourage material reuse and recycling by putting an emphasis on affordability and resource optimisation.	Le Bas (2016) and Ezeudu et al. (2022)
Collaboration (C16)	Collaboration plays a vital role in pushing a circular economy infrastructure by facilitating multilevel collaboration, intermediaries, and co-designing platforms, businesses and communities can overcome barriers and implement circular practices.	Meath et al. (2022), Hofstetter et al. (2021), and Köhler et al. (2022)

2.14 Local production

The concept of embracing local production involves the ability to facilitate the establishment of closed-loop processes, which can efficiently reduce the development of waste and optimise the utilisation of resources (Arsova et al., 2022). The utilisation of local resources, the reduction of emissions from transportation, and the creation of employment possibilities within the local community are all made possible owing to the promotion of local production, which plays a crucial role in the promotion of the growth of a circular economy (Arruda et al., 2021). The implementation of a localised production plan has the capacity to optimise resource utilisation, reduce the formation of waste, and promote circularity within businesses (Velenturf and Purnell, 2021).

2.15 Effective waste management

The deployment of effective waste management strategies enables the recovery and subsequent utilisation of materials that could have been discarded, thus making a significant contribution to waste reduction, resource preservation, and the alleviation of environmental impacts linked to production and consumption (González-Sánchez et al., 2023). The circular economy endeavours to achieve the closure of the material loop and the reduction of virgin resource extraction by retrieving materials from products at the conclusion of their life cycle and repurposing them into new products or (Reike et al., 2018). Efficient waste management practices not only contribute to the reduction in the need for primary resources but also lead to a decrease in energy utilisation and the release of greenhouse gases linked to the manufacturing of fresh materials (Yang et al., 2023).

2.16 Collaboration

Collaboration facilitates the establishment of closed-loop systems that effectively reduce waste and optimise the utilisation of resources (Meath et al., 2022). Engaging in the practice of pooling, sharing, and reusing both tangible and intangible resources, businesses and communities can enhance the efficiency of resource utilisation, minimise wastage, and foster the concept of circularity (Hofstetter et al., 2021). Collaboration has an opportunity to generate concrete advantages for emerging economies and effectively tackles the obstacles associated with supply chain collaboration in the realm of circular economy investigation. It is essential for advancing circular economy practices and achieving sustainability objectives overall. It also assists with addressing supply chain collaboration challenges, enhancing sustainability performance, and enabling organisations to reach circular economy objectives (Köhler et al., 2022).

3 Methodology

3.1 Interpretive structural modelling

The concept of interpretive structural modelling (ISM) was first put forward by Warfield (1973) as a method for examining intricate socioeconomic systems. ISM is a dynamic computer-assisted learning process that structures a set of heterogeneous, directly related elements into an integrated systematic model. ISM also provides the fundamental concepts for developing a map of the complex relationships between all the different components involved in multifaceted situations. Utilising the practical experience and knowledge of experts to decompose a complex hierarchy into numerous sub-systems and construct a multi-tiered structural form is the central concept of ISM. (Raj et al., 2008) centred on an ISM strategy to identify the collaboration of the manufacturing competing enablers that contribute to the success of the manufacturing sector, as well as the driving and dependent enablers. The following ISM characteristics:

1. this methodology is interpretive as the judgment of the group decides whether and how the different elements are related
2. it is structural, too, on the basis of relationship; an overall structure is extracted from the complex set of variables
3. it is a modelling technique, as the specific relationships and overall structure are portrayed in a digraph model
4. it helps to impose order and direction on the complexity of relationships among various elements of a system
5. it is primarily intended as a group learning process, but individuals can also use it.

The reason behind choosing ISM are as follows:

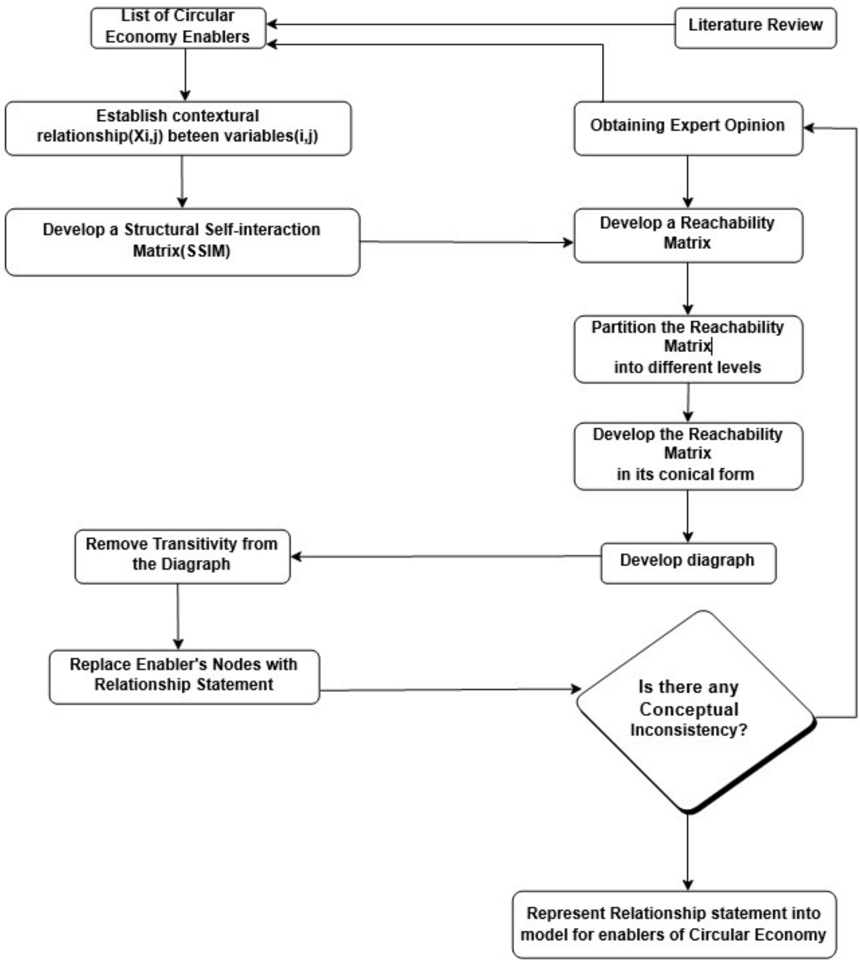
- an interpretive structural model can be used to determine the relationship between drivers who depend on one another either individually or as a group
- ISM breaks down criteria into distinct levels to examine the interaction between them (Kannan et al., 2009)
- ISM can be used to examine how various variables that are defined for a problem relate to one another.

The ISM technique offers numerous advantages; nonetheless, it is not without its limitations or shortcomings. The primary constraints of ISM are to the extent to which the interconnections among variables are contingent upon the users' expertise and industry-specific experience. Hence, the presence of bias in the individual responsible for evaluating the factors has the potential to influence the ultimate outcome. The following steps are concerned with the ISM methodology are (Kannan et al., 2009):

- Variables (criteria) considered for the system under consideration are listed.
- From the variables identified in step 1, a contextual relationship is established among the variables in order to identify as to which pairs of variables should be examined.
- A SSIM is developed for variables, which indicates pairwise relationships among the variables of the system under consideration.
- Reachability matrix is developed from the SSIM, and the matrix is checked for transitivity. The transitivity of the contextual relation is a basic assumption made in ISM. It states that if a variable A is related to B and B is related to C, then A is necessarily related to C.
- The reachability matrix obtained in step 4 is partitioned into different levels.

- Based on the relationships given above in the reachability matrix, a directed graph is drawn, and the transitive links are removed.
- The ISM model developed in step 7 is reviewed to check for conceptual inconsistency and necessary modifications are made.

Figure 1 ISM flowchart (see online version for colours)



3.2 Data collection

To establish qualitative connections between variables, ISM methods are used which include the use of expert perspectives using varied management strategies, including brainstorming, nominal strategies, etc. To identify the contextual relationship among facilitators, ten experts from industries and twenty academicians were consulted. A contextual relationship of the type 'conducts to' is selected for the analysis of drivers. It means that one facilitator contributes to another facilitator. This led to the development of contextual relationships between enablers.

4 Application of ISM

4.1 Structural self-interaction matrix and reachability matrix

Circular consumption practices literature has been reviewed to better understand how consumers conceptualise this concept. Expert opinions from the business and academic realms are gathered for this. There were 30 competitors in all, representing several disciplines. SSIM, which uses four symbols to represent the current common relationship between the objects that are exhibited horizontally (i) and vertically (j), is used to analyze the contextual relationship. ISM has been used to highlight the structures that support simplicity. By ranking the drivers or enablers, we may decide which enablers are most crucial. To achieve our minimalist goal, we identified the most important enablers using the ISM technique. The ISM technique is a qualitative approach that adheres to an algorithm with predetermined phases. The reachability matrix and the SSIM matrix are included in this methodology (Table 3). The following is a description of the ISM approach's symbols:

V i assist in the j element's completion

A j provides direction for completing the i element

X i and j element guide each other in accomplishment

O the elements i and j are not related.

To establish qualitative connections between variables, ISM methods – which make use of expert viewpoints and a range of management strategies, such as brainstorming, nominal tactics, etc. – are used. Young customers are driving a populace that is increasingly ecologically aware. The table explains the four SSIM symbols. Element i (1) is shown in cell (1, 16), which has the symbol V, and leads to element j (16). Consequently, symbol V is used in these situations when i lead j.

The next step in SSIM is to translate symbols into binary digits (0, 1). The binary matrix that results from conversion is known as the initial matrix of reachability. Several sets of guidelines are followed during the conversion process and are listed below:

1 in the initial matrix of reachability, cell (i, j) with the V symbol in SSIM accepts the binary digit '1', and '0' in the case of (j, i)

2 additionally, a cell (i, j) with an A symbol will accept '0' in the matrix of initial reachability, and in that case, (j,i) will be '1'

3 in the initial matrix of reachability, both cells will accept a binary digit of '1' if (i, j) and (j, i) are represented by the character X.I

4 the binary digit '0' is required if the cell (i, j) is defined by O.

After the SSIM matrix has been finished, the reachability matrix comes next. The SSIM matrix is converted to a binary matrix of 1 and 0 via the reachability matrix (Table 3). All four symbols (V, A, X, and O) are converted into binary form based on predetermined criteria. In the i, j and j, i cells of the matrix, 1, 1 will take the place of X if it occurs on the SSIM matrix.

Table 2 SSIM matrix

	C16	*C15*	*C14*	*C13*	*C12*	*C11*	*C10*	*C9*	*C8*	*C7*	*C6*	*C5*	*C4*	*C3*	*C2*	*C1*
C1	A	V	X	O	V	A	A	O	V	V	O	V	X	X	A	
C2	V	O	O	V	V	V	O	O	V	V	O	V	V	V		
C3	O	V	V	V	X	A	V	V	V	V	O	O	O			
C4	V	V	O	V	V	A	O	V	V	V	V	O				
C5	V	V	A	V	V	A	V	V	V	V	O					
C6	A	A	A	A	O	O	V	A	A	A						
C7	A	X	V	A	A	A	V	O	O							
C8	O	A	V	V	V	A	V	V								
C9	A	A	A	O	A	A										
C10	A	A	X	A	A	V										
C11	V	X	A	V	V											
C12	O	V	V	O												
C13	O	A	O													
C14	O	O														
C15	X															
C16																

Source: Authors calculation

Table 3 Reachability matrix

	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	*C16*
C1	1	0	1	1	1	0	1	1	0	0	0	1	0	1	1	1
C2	1	1	1	1	1	0	1	1	0	0	1	1	1	0	0	1
C3	1	0	1	0	0	0	1	1	1	1	0	1	1	1	0	0
C4	1	0	0	1	0	1	1	1	1	0	0	1	1	0	1	1
C5	0	0	0	0	1	0	1	1	1	1	0	1	1	0	1	1
C6	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
C7	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0
C8	0	0	0	0	0	1	0	1	1	1	0	1	1	1	0	1
C9	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0
C10	1	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0
C11	1	0	1	1	1	0	1	1	1	0	1	1	1	0	1	1
C12	0	0	1	0	0	0	1	0	1	1	0	1	0	1	1	0
C13	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0
C14	0	0	0	1	1	1	0	0	1	1	1	0	0	1	0	0
C15	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1	0
C16	0	0	0	0	0	1	1	0	1	1	0	0	0	0	1	1

Source: Authors calculation

Transitivity analysis is incorporated into the matrix to ensure correct output before coming to the final reachability matrix. The complete matrix of reachability is shown below:

Table 4 Final reachability matrix

	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	*C16*	*Driver*
C1	1	0	1	1	1	1*	1	1	0	1*	0	1	1	1	1	1	13
C2	1	1	1	1	1	0	1	1	0	0	1	1	1	0	0	1	11
C3	1	0	1	0	1*	0	1	1	1	1	0	1	1	1	1	0	11
C4	1	0	0	1	0	1	1	1	1	0	0	1	1	0	1	1	10
C5	0	1*	0	0	1	0	1	1	1	1	0	1	1	0	1	1	10
C6	0	0	1	1	0	1	0	0	0	1	1*	0	0	0	0	0	5
C7	1*	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	5
C8	0	1*	1*	0	0	1	0	1	1	1	0	1	1	1	0	1	10
C9	0	0	0	0	0	1	0	0	1	1	0	1*	0	0	1*	0	5
C10	1	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	4
C11	1	0	1	1	1	0	1	1	1	0	1	1	1	1*	1	1	13
C12	0	0	1	0	0	1*	1	0	1	1	0	1	0	1	1	0	8
C13	0	1*	0	1*	0	1	1	0	0	1	0	0	1	0	0	0	10
C14	0	0	0	1	1	1	0	0	1	1	1	0	0	1	0	0	9
C15	0	0	1*	0	0	1	1	1	1	1	1	0	0	0	1	0	8
C16	1	1*	0	1*	0	1	1	1	1	1	0	0	0	0	1	1	8
Dependence	8	5	8	8	6	11	11	9	10	13	6	9	7	8	8	7	

Source: Authors calculation

Table 5 Level partition

Variables	*Reachability set*	*Antecedents set*	*Intersection*	*Level*
1	1, 3, 4, 5, 6, 7, 8, 10, 12, 14, 15, 16	1, 2, 3, 4, 7, 10, 11	1, 3, 4, 7, 10	III
2	1, 2, 3, 4, 5, 7, 8, 11, 13, 16	2, 5, 8, 13, 16	2, 5, 8, 13	IV
3	1, 3, 5, 7, 8, 9, 10, 12, 13, 14	1, 2, 3, 6, 8, 11, 12, 15	1, 3, 8, 12	V
4	1, 4, 6, 7, 8, 9, 12, 13, 15, 16	1, 2, 4, 6, 11, 13, 14, 16	1, 4, 6, 13, 16	III
5	2, 5, 7, 8, 9, 10, 12, 13, 15, 16	1, 2, 3, 5, 11, 14	2, 5	IV
6	3, 4, 6, 10, 11	1, 4, 6, 7, 8, 9, 12, 13, 14, 15, 16	4, 6	III
7	1, 6, 7, 10, 14	1, 2, 3, 4, 5, 7, 11, 12, 13, 15, 16	1, 7	II
8	2, 3, 6, 8, 9, 10, 12, 13, 14, 16	1, 2, 3, 4, 5, 8, 11, 15	2, 3, 8	II

Source: Authors calculation

Table 5 Level partition (continued)

Variables	*Reachability set*	*Antecedents set*	*Intersection*	*Level*
9	1, 9, 10, 12, 15	3, 4, 5, 8, 9, 11, 12, 14, 15, 16	9, 12, 15	II
10	1, 10, 14	1, 3, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16	1, 10, 14	I
11	1, 3, 4, 5, 7, 8, 9, 11, 12, 13, 14, 15, 16	2, 6, 10, 11, 14, 15	11, 14, 15	IV
12	3, 6, 7, 9, 10, 12, 14, 15	1, 2, 3, 4, 5, 8, 9, 11, 12	3, 12	IV
13	2, 4, 6, 7, 10, 13	2, 3, 4, 5, 8, 11, 13	2, 4, 13	IV
14	4, 5, 6, 9, 10, 11, 14	1, 3, 7, 8, 10, 11, 12, 14	10, 11, 14	V
15	3, 6, 7, 8, 9, 10, 11, 15	1, 4, 5, 9, 11, 15, 16	9, 11	VI
16	2, 4, 6, 7, 9, 10, 15, 16	1, 2, 4, 5, 8, 11, 12, 16	2, 4, 16	VI

Source: Authors calculation

The final matrix (Table 4) is created in order to retrieve the set of reachability and the set of antecedents. In order to find intersection sets that include all of the elements, both sets offer aid. The ISM hierarchy is produced by matching the intersection set and reachability set (Table 5). A strongly matched set is given the top ranking in this case, and so on.

Figure 2 Driver power and dependence power

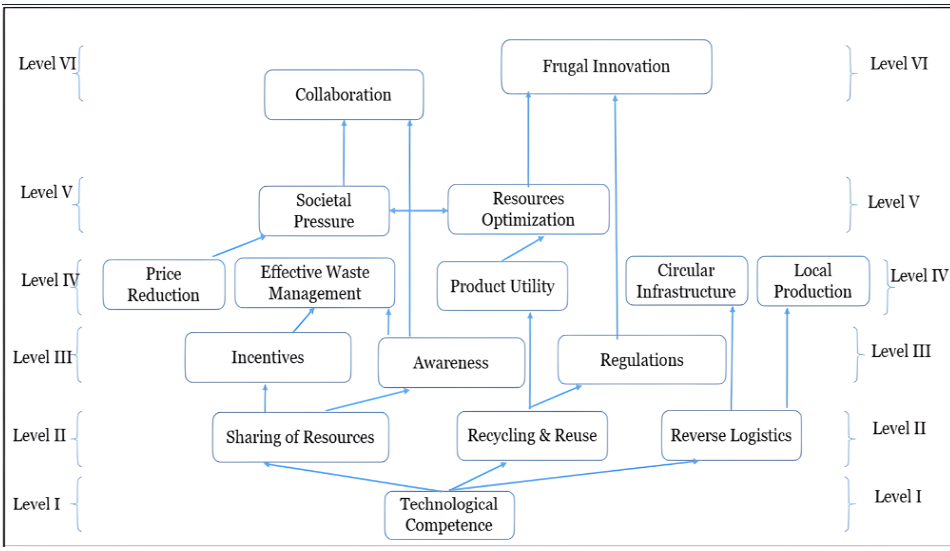
13		C4											
12													
11		**Independent**											
10													
9			C1	C5					**Linkage**				
8			C7		C10								
7					C11		C17		C13				
6			C2				C9						
5										C16			
4							C14						
3		**Autonomous**							C8				
2									C12				
1	C15						**Dependent**			C6	C3		
Driving Power	1	2	3	4	5	6	7	8	9	10	11	12	13
						Dependence Power							

4.2 MICMAC analysis

MICMAC is used to examine the driving and dependence power of the variables. The variables have been classified into four categories called as autonomous, linkage, dependent and driving variables (Table 7). The following is the meaning of the four categories:

- *Autonomous variable:* this indicates a weak driving power and subsequently a weak dependence power. The variables are disconnected from the system.
- *Linkage variable:* this indicates a strong driving and strong dependence power. The factors are unstable; any action on these variables will have an effect on others and a feedback effect on themselves.
- *Dependent variable:* this indicates a weak driving power but strong dependence power. Any action on them will have an effect on others and also feedback effect on themselves.
- *Independent variable:* this indicates a strong driving power but weak dependence power.

Figure 3 ISM model for circular economy (see online version for colours)



5 Results and discussion

In the pursuit of a sustainable future and the mitigation of environmental degradation, the concept of a circular economy has emerged as a promising paradigm. The present study utilises the ISM methodology to examine the intricate interconnections between crucial variables that influence circular economy initiatives. Some of the most impactful variables under scrutiny include technological competence, reverse logistics, and awareness as independent variables, sharing of resources as the dependent variable, and recycling and reuse as the linkage variable. The results of the study analysis revealed that technological competence and awareness were the most influential variables in the circular economy, with high driving power and low dependence power. Sharing of resources was found to be a dependent variable, indicating that it is influenced by other variables in the system. Recycling and reuse was identified as a linkage variable, indicating that it plays a mediating role between other variables. Finally, reverse logistics was found to be an independent variable, indicating that it has a direct impact on other variables in the system.

The results of this study have important implications for the development of circular economy strategies. The high driving power of technological competence and awareness suggests that efforts to promote these variables will have a significant impact on the circular economy. This finding aligns with the growing recognition of technology's potential to enhance resource efficiency and reduce waste generation (Khan et al., 2022). Companies and organisations that possess a greater level of technological competency are more adept at developing innovative goods and processes that prioritise the principles of recycling and reuse (Mendoza et al., 2022). Furthermore, the utilisation of advanced technologies plays a crucial role in the successful execution of reverse logistics strategies. Policymakers should invest in education and training programs to improve technological competence and awareness among stakeholders. Additionally, companies need to develop innovative technologies and business models that promote circularity and raise awareness among consumers (Rehman Khan et al., 2022).

The identification of sharing of resources as a dependent variable highlights the importance of collaboration and cooperation in the circular economy. To promote sharing, policymakers must develop regulations and incentives that encourage companies to share resources and collaborate on circular economy initiatives. Additionally, companies could develop sharing platforms and business models that promote the sharing of resources among stakeholders (Jayakumar et al., 2020). Recycling and reuse as a linkage variable suggests that efforts to promote recycling and reuse could have a positive impact on other variables in the system. For example, companies could develop closed-loop supply chains that promote recycling and reuse, while policymakers could develop regulations and incentives that encourage companies to adopt circular business models.

Furthermore, reverse logistics has emerged as an essential contributing factor in the progression of circular economy operations. The logistics of returning, remanufacturing, and recycling products and materials can lead to substantial reductions in waste and environmental impact (Butt et al., 2023). Further reverse logistics as an independent variable suggests that efforts to improve reverse logistics could have a direct impact on the circular economy. Companies should develop efficient reverse logistics systems to promote the recovery and reuse of materials, while policymakers could develop regulations and incentives to encourage companies to adopt circular business models. The utilisation of advanced technologies plays a crucial role in the successful execution of reverse logistics strategies, as it allows for the effective recovery and repurposing of products and commodities (Mayanti and Helo, 2024).

To date, a lot of nations and companies have focused their strategies for reaching net-zero emissions around an energy transition, which entails increasing energy efficiency and quickening the switch to renewable energy sources. In order to achieve net zero, nations and companies should also think about implementing what is referred to as a 'materials transition', which would entail applying circular economy principles to maximise the use and repurposing of these materials in addition to implementing lower-impact methods of material production. The significance of sustainable procurement in greening humanitarian interventions is emphasised by circular practices. Encouraging circular practices will improve the selection of appropriate products and relevant service aspects (e.g., recyclability, reparability) to minimise waste, prolong product lifecycles, and lessen any ultimate downstream effects of disposing of waste from products that are purchased. This will assist in reaching net zero emissions even more.

6 Theoretical contribution

The establishment of formal connections among these variables constitutes a noteworthy advance within this field. The linkages have been classified based on their influence in driving power and reliance power relative to other enablers. The ISM-based model illustrates a hierarchical structure that demonstrates the varying degrees of significance among different enablers as drivers. Additionally, there are enablers that exhibit a moderate level of dependence, occupying an intermediate position within the hierarchy. The enablers at equivalent levels suggest that they possess equal significance. This paper contributes to the existing body of literature on the circular economy by incorporating additional dimensions, namely societal pressure, reverse logistics, and product utility.

Social pressure for sustainable products and services encourage businesses to adopt circular practices. The collection and processing of discarded goods and materials through reverse logistics assists to save resources and reduce waste. Product utility – the ability to reuse, repair, or recycle, extends product lifespan, and reduce the necessity for virgin materials. These factors possess the potential to facilitate businesses in establishing long-term sustainability and making substantial contributions to the circular economy. The present study emphasises the theoretical contribution by examining the key variables which impact the shift towards the circular economy and circular infrastructure.

7 Implications

The circular economy aims to recover and conserve materials throughout the production and consumption phases. Numerous studies have shown how CE helps firms find new markets while simultaneously benefiting the environment. The study's findings would aid practitioners in putting circular business practices into use, which would optimise resource efficiency and guard against unsustainable consumption. Additionally, it will support the concept of a circular business model, which enhance eco-efficiency and lead to greener production. The recycling and reuse of production waste would support sustainable manufacturing.

Going by environmental and social implications, the study findings help in improving the health of environment. Product reuse and recycling decrease the loss of biodiversity, lessen disturbance of the environment and habitats, and slow down the usage of natural resources. Reduced annual greenhouse gas emissions are another advantage of the circular economy that will be achieved by adopting circular practices. The circular economy provides the means by which people may jointly solve critical socioeconomic needs and combat climate change and biodiversity loss. It empowers us to reduce waste, pollution, and greenhouse gas emissions while increasing resilience, wealth, and employment.

The finding will help in enhancing the knowledge and comprehension of the elements that promote the adoption and execution of circular practices by examining the drivers and facilitators of the circular economy. These insights provide valuable information for policymakers, corporations, and other stakeholders as they develop strategies and actions to expedite the shift towards a more sustainable and the circular economy in general.

8 Limitations and direction for future research

The primary limitation of this work is that it only uses the ISM technique to analyze the relationships. The study's second flaw is that it only includes five professionals, making it little tough to generalise the results. Another limitation, considering that just sixteen elements have been looked at, is that there might be more important ones that are accountable for the transition from linear models to circular economies, but they have not yet been recognised and categorised. Future research may investigate the impact of circular behaviour on happiness, productivity and well-being of people. Furthermore, since society also influences decisions and shapes consumer behaviour, studying how societal variables affect the behaviour of immature millennials can be a topic for future study. Future studies should look at the integration of other circular behaviour tenets into marketing communications, such as decluttering, conscious consumption and aesthetic sparsity.

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