Drivers of Circular Economy for Small and Medium Enterprises: Case Study on the Indian State of Tamil Nadu

Abstract

This case study on Tamil Nadu state in India highlights the growing relevance of Circular Economy (CE) adoption by Small- and Medium-sized Enterprises (SMEs) and the relationship between the drivers of CE. This paper analyses the drivers and the interactions between the different drivers as well as comments on the challenges and benefits of CE adoption for Tamil Nadu state. An analysis for Tamil Nadu is relevant and timely as this state ranks first in terms of the number of SMEs while facing the twin challenge of rapid urbanisation and resource depletion. Using Total Interpretive Structural Modelling (TISM) and Cross-Impact Matrix Multiplication Applied to Classification (MICMAC), this paper identifies the main drivers that impact the uptake and adoption of CE by SMEs and comments on the driving, dependent and linking elements from SMEs perspective. The review of literature identifies 18 drivers as relevant for CE adoption. Ten drivers are identified relevant for SMEs in Tamil Nadu based on discussions with 78 industrial and academic experts. This research provides multi-fold theoretical contributions to the existing knowledge in the research area of drivers of circular economy adoption in general and it is the first of its kind to establish contextual linkages between the identified drivers using novel TISM and MICMAC techniques which also gives researchers a sense of interrelationships between adoption drivers. The validation and modelling results confirm that three drivers are highly relevant for successful adoption of CE, these are population and urbanisation, funding availability offered for CE projects, and growing resource consumption.

Keywords: Circular economy, Small and Medium Enterprises, Drivers, Total Interpretive Structural modelling, MICMAC

1. Introduction

Increasing global population and growing natural resources exploitation together with smaller product lifecycle are important challenges that accelerated the depletion of resources (Bakker et al., 2014). The threat of depletion is compounded by the existing linear 'make-use-dispose' model of production and consumption which has resulted in an acute shortage of raw materials (Chertow and Ehrenfeld, 2012). Further, the growing waste and resource scrappage along with high consumerism poses an additional threat with potential environmental and human health concerns (Blomsma and Brennan, 2017). Finally, environmental problems, such as the loss of biodiversity and resource depletion threatens earth's life-support systems with long term implications (Chen et al., 2012). Considering rapidly depleting resources, studies stress on the importance to identify new and efficient initiatives and suggest alternatives for a sustainable future (Cohen and Muñoz, 2016). To prevent the depletion of resources, closing energy and material loops and facilitating sustainable development at enterprise and consumer level as well as promoting industrial symbiosis in macro-cities, regions and governmental levels have been recommended (Kirchherr et al. 2017). In this context the global emphasis on Circular Economy approach has increased and an emerging economy such as India is bracing itself towards circular business models to recover lost resources and retain the expended ones. CE is an approach that promotes responsible and cyclical use of resources that decouples economic growth from resource extraction and environmental losses (Smol et al., 2021).

The European Environment Agency (EEA) defines CE as: "The concept that can, in principle, be applied to all kinds of natural resources, including biotic and a-biotic materials, water and land. Eco-design, repair, reuse, refurbishment, remanufacture, product sharing, waste prevention and waste recycling are all important in a circular economy" (EEA 2016: 9).Thus, CE addresses resource depletion by implementing eco-efficient measures that reduce the consumption of non-renewable resources which enable them to retain the value for longer

period (Guerra and Leite, 2021). Within the supply chain context, the CE model focuses on aligning and managing resource flows across the value chain by integrating reverse logistics, design innovation, collaborative ecosystems and business innovation models (Mangla et al., 2019). CE also drives companies to redesign their supply chain for environmental (Genovese et al. 2017), social (Ongondo et al. 2013), and economic benefits (Cucchiella et al. 2015). Further, CE addresses the United Nations Sustainable Development Goals (SDGs), the ones particularly relevant for CE are SDG1 - no poverty, SDG2 - Zero hunger, SDG7 - Affordable and clean energy, SDG9 - promotion of inclusive and sustainable industrialisation and innovation, SDG 11 - sustainable cities and communities, and SDG12 - responsible consumption and production (MacArthur 2015). Hence, many countries focusing on sustainable development are considering the adoption of CE strategies but the uptake of the circular business models is proving challenging (Mangla et al, 2019; Gedam et al., 2021). Parida et al., (2019) developed a qualitative study-based process model of ecosystem transformation based on readiness assessment and ecosystem transformation for CE adoption. Fehrer & Wieland, (2020) in the systematic literature review summarised the adoption rates of CE business models and developed fundamental propositions which identify the requirements for operationalising CE. Confente et al., (2020) developed a conceptual model addressing psychological drivers that encourage consumers' intention for transition from a linear to a circular economy. Kristoffersen et al., (2020), developed a theory-and practice-based smart CE framework to support manufacturing companies to translate CE strategies into firm's goals. The rationale for CE adoption is much more relevant in developing countries' context which are faced with pressures of growing population and dwindling resources given these countries will account for 90% of total global population by 2050 (Chaudhary and Vrat, 2018; Haub, 2012). In emerging economies the adoption of CE practices is closely linked with consumer behaviour and their acceptance of remanufactured products and using products as services

(Patwa et al., 2020). Further, the use of CE in SMEs offers solutions to waste minimisation and planning energy usage to reduce supply chain related risks (Mangers et al., 2021; Mura et al., 2020).

CE has great potential for India as an emerging economy that consumed about 42% renewable biomass and 38% non-metal minerals (IRP, 2017). To be able to sustain its high growth rate and continue the trajectory of development without exacerbating the resource shortages the adoption of CE is a necessity (Prasad and Manimala, 2018). This is especially relevant to SMEs that contribute 45% of the industrial output and 40% of total exports to support the socio-economic development of India (Sahu et al., 2021). The adoption of CE provides a potential solution for sustaining high economic growth rate without straining the resource requirements (Bocken et al., 2016; Husain et al., 2021). The document 'Accelerating India's Circular Economy Shift' (2018), states that almost half-a-trillion-dollars of Gross Domestic Product (GDP) can be protected by adopting CE in India by 2030. Despite the economic importance in Indian economy, the uptake of the CE by Tamil Nadu is low given the uncertainty in demand and supply scenarios which makes it difficult for SMEs to focus on sustainability and circularity. Research confirms that SMEs in India struggle to adopt circular business models effectively (Singh et al., 2018). This is a case study on Tamil Nadu state in India that ranks first in terms of number of SMEs, factories and industrial workers with a diversified manufacturing sector that produces a range of products, ranging from automobiles and auto components, engineering, pharmaceuticals, garments, textiles, leather products, chemicals to plastics. The state is the fourth largest Indian state with a well-developed infrastructure coupled with excellent connectivity via rail, air and sea, which makes it the manufacturing hub. The focus of this research is SMEs in Tamilnadu state, and we aim to study the adoption drivers of CE in focus with the Automobile, Textile, Electronics, Tourism and Educational sector in the state. The reason behind this is not only these sectors are major contributors to the GDP of India but

also, TamilNadu is the second highest contributor to the country's GDP which is the leader in the above-mentioned sectors. For instance, the textile sector contributes to more than 7% of the nations industrial output and TamilNadu owns one third of this sector with numerous SMEs operating in sub sectors such as spinning, handloom weaving, power loom weaving, processing, knitwear, apparel and garmenting (Govt of Tamil Nadu, 2019). This forms the essential focus points where emphasis on adopting CE could reap huge benefits and also the successful adoption in TamilNadu could show the path towards CE to the other states. In reference to automobile sector, TamilNadu owns 35-40% of the nation's automobile industries which provides a huge scope for CE adoption. In addition, Tamil Nadu's tourism industry ranks first in terms of domestic tourist arrivals and second in terms of foreign tourist arrivals. Similarly, the state excels in electronics, and educational sectors and always looked like a role model to the other states of India. Hence, the diversely developed state has massive potential to gain huge benefits from CE adoption and provides us with an excellent base to conduct this research.

Though large organisations have started adopted CE the uptake by SMEs is slow primarily due to the lack of efficient business intelligence capabilities for market analysis and service platforms (Dey et al., 2020; Ezedu et al., 2021). Hence, this paper identifies drivers for the successful adoption of CE by Indian SMEs especially in TamilNadu state. The contribution of the research is three-fold: first, this research is first of its kind to explore and explain the adoption of CE in SMEs. The main drivers of CE based on an exhaustive literature review. Secondly this research establishes the contextual relationships between the identified adoption drivers with help of novel Total Interpretive Structural Modelling (TISM) approach. None of the existing research studies have examined interrelationships between drivers and further the MICMAC approach is employed to classify the drivers into driving, dependent, autonomous and linkage categories to understand their nature. Finally, this study aims in offering

implications to managers in terms of what CE could bring to the table and the adoption drivers the managers should pay attention to successfully adopt CE in Indian SMEs.

This paper addresses the following research questions.

RQ1: What is the need for circular economy adoption in India?

RQ2: What are the potential drivers that highlight the importance for of circular economy in Indian SMEs?

RQ3: What are the interactions and contextual relations between the drivers?

Thus, our work develops a contextual relationship-based performance model to analyse the drivers that facilitate the adoption of CE in Indian industries and understand the interactions between the different drivers.

The remainder of the paper is structured as follows. Section 2 addresses the rationale for CE adoption in India and discusses the potential drivers. Section 3 details the application of TISM methodology and develop the conceptual framework of drivers for CE adoption by Indian SMEs. Section 4 presents the results, classifies the drivers using validated TISM model and findings of discussions with experts. The conclusion is presented in section 5. The limitations of our work and suggestions for future work are discussed in section 6.

2. Research Background

2.1 Rationale for circular economy in India

India is among the fastest growing economies, with an average annual growth of 7.4% in the last decade and has nearly 18% of the total world population. It is estimated that India will be the fourth largest economy in the world by2030 (Ellen MacArthur Foundation, 2016). India underwent a rapid structural transition from an agrarian to a services-based economy which resulted in growing urbanization leading to high consumption of both renewable and non-renewable resources which contributed to resources scarcity (Dittrich, 2012; Anil et al., 2014). The extraction of primary raw materials increased by around 420% between 1970 and 2010

(UNEP, 2013) and the 'make-use-dispose' model together with growing population has exacerbated the demand-supply gap (IGEP, 2013).

India spends around 120 billion USD annually on importing crude oil and its dependency on petroleum has increased 8% over 2010-2020 (FICCI, 2018). India's plastic consumption is expected to grow to 20mn tons by 2020 and about 40% of the plastic wastes eventually end in landfills (IGEP, 2013). According to the National Steel Policy 2017, India is estimated to consume 160 kilograms per capita by the end of 2030 (Economic times India, 2017). However, iron ore production lags behind the demand and iron ore reserves are expected to exhaust by the next ten years makes India a net importer of iron ore (World Steel, 2017). Similarly, the demand for copper in growing at a rate of 7% till 2030 and India just contributes to only 2-3% of the world's reserves for copper (Indian Bureau of Mines, 2016). Indian consumers account for around 650 tons of gold in 2017 whilst the domestic production only met 0.2% of the total demand (Ministry of Mines, 2018) constituting an import bill of 35 billion US dollars (FICCI, 2018). In case of cement, India is the second largest producer, but the consumption is estimated to exceed the supply over the coming years (IBEF, 2017). India's food wastes including production, consumption and sales contribute to 46.5 megatons per year (World Economic Forum, 2015). The consumption patterns observed over 2010-20 suggest that Indian consumers keep their clothing only half as long (Remy et al., 2016).

In this light, the SMEs are bound to consume the majority of the above share of resources and adoption of the CE can be a solution to the problems associated with urbanisation and industrialisation (Ellen MacArthur Foundation, 2016). The CE approach favours steady economic development without significant environmental and resource depletion (Clark et al., 2016). "A circular economy is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles" (Ellen MacArthur Foundation, 2016).

CE in SMEs can support India to build a regenerative and restorative economic model in which resources have long-term value (Geng et a., 2009). The Indian government has initiated an ambitious program to support the UN SDGs by adopting circular economy. The Circular Economy Mission to India, 2018 marked the launch of collaboration between India and EU towards the CE. The Federation of Indian Chambers of Commerce and Industry (FICCI) in collaboration with experts from EU identified potential areas to build partnerships for resource efficiency models. In this regard, the 13th Sustainability Summit organised by Confederation of Indian Industry (CII) marked the inauguration of the Circular Economy Mission to India 2018 that aimed at creating awareness amongst Indian industries especially in SMEs.

With increasing urbanisation and a disproportionate increase in material wastes CE models have been proposed as the solution for India (Ellen MacArthur foundation, 2016). But the adoption of CE requires a systemic orientation for all the stakeholders, including government institutions, corporations, nongovernmental organisations (NGOs), civil society organisations, development agencies, and individuals (Chertow and Ehrenfeld, 2012). Ensuring recovery and recycling of resources from scrapped products and increasing the product lifecycle by repairing, remanufacturing, upgrading and reselling are the common CE approaches highlighted as the 'go-to' in literature (Su et al. 2013; Geng et al. 2012; Franklin-Johnson et al., 2016; Reuter, 2016; Pan et al., 2015). A sharing platform model generates CE by promoting shared use and ownership of products (Cohen and Muñoz, 2016) and allow paying for use, leasing, renting and performance agreement by promoting access over ownership (Tukker, 2015). Figure 1 presents the CE business models for India.

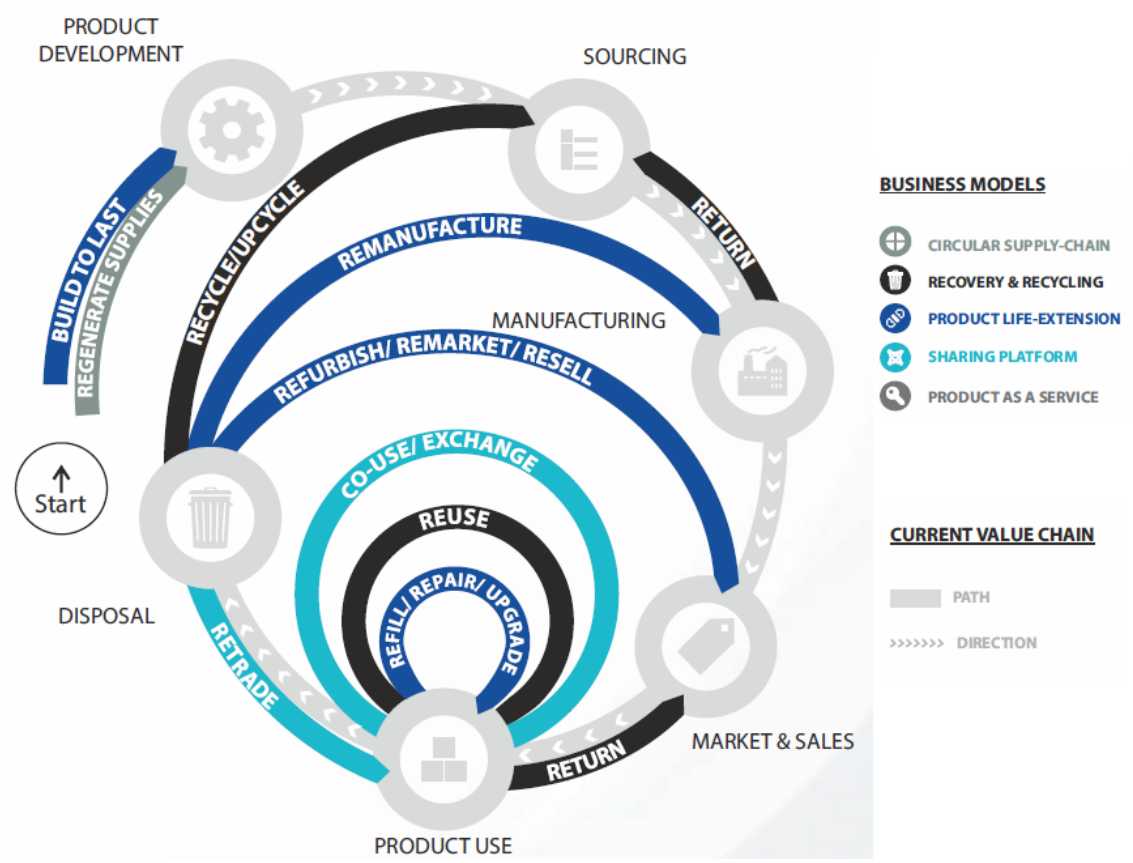

Figure 1. Circular economy business models. (adopted from Accelerating India's Circular Economy Shift, FICCI, Circular Economy Symposium 2018)

2.1.1. Circular Economy in India

Though CE has been the buzz word for over a decade, focus on research and adoption of CE in India is in infancy. Researchers focus on the general concepts of CE within a country specific context without an exhaustive discussion on the drivers. Govindan and Hasanagic (2018) conducted a systematic literature review and explored the drivers, barriers and practices of circular economy by focusing mainly on circular supply chains. Masi et al. (2017) explored various supply chain configurations through a systematic literature review. Ranta et al., (2018) explored the institutional drivers and barriers of circular economy and conducted a cross regional comparison for its adoption in China, US and Europe. de Jesus and Mendonça (2018) analysed the drivers and barriers in the eco-innovation road to circular economy while Upadhyay et al., (2021) explored the same in the context of mining industry. Salim et al. (2019) compiled a report on drivers, barriers and enablers to end-of-life management of solar

photovoltaic and battery energy storage systems while Mehamood et al., (2021) summarised the drivers and barriers towards CE in agri-food supply chain. Liguori and Faraco (2016) reviewed the bio-treatment concepts that promote circular economy. Lieder and Rashid (2016) summarised the status of circular economy in manufacturing context focusing on eco-efficient practices and interestingly de Morais et al., (2021) addressed the engagement of CE in the light of Altruism, status, and cultural orientation. Lewandowski (2016) proposed a conceptual framework of business models for effective implementation of circular economy focusing on the adoption factors.

Within country-specific contexts, Matus et al. (2012) identified the factors driving innovation in green chemistry and green engineering driven by circular economy in China. Mathews and Tan (2011) summarised China's progress in circular economy by evaluating the drivers for the systematic promotion of eco-industrial initiatives. Ilić and Nikolić (2016) analysed the bottlenecks that restrict Serbia's sustainable development by adopting CE. De Mattos and de Albuquerque (2018) identified and analysed the enabling factors and strategies for the structuring and diffusion of a circular business model in a Brazilian context. Moktadir et al., (2018) used a graph theory approach to examine the drivers of circular economy for leather industries in Bangladesh. Chirenjeevi et al. (2018) analysed the opportunities for waste derived circular bio economy in an Indian perspective. Fiksel et al., (2021) argued that achieving resilience through adopting CE would require enlightened government policies and innovative pathways for utilizing discarded materials through an Indian case study approach. Priyadarshini et al., (2020), examined the linkages between CE boosting policy setup and sustainable development in the context of Indian waste management sectors providing insights on aligning regulations with CE policy to reap its benefits in India. Kakwani and Kalbar (2020) summarised the CE challenges and opportunities in urban water sector of India and highlighted the need for a framework to monitor CE implementation. But the existing literature is void of

any research which analyses the adoption drivers for successful implementation of CE and our research is aimed at filling this void by identifying the drivers potentially boost the successful implementation of CE in Indian SME context and aims at understanding the interrelationships between the driving elements.

2.1.2. Barriers to CE adoption in India

Though barriers against the CE adoption in India is not the focus of this research, it is necessary to understand from a managerial point of view what are the challenges involved in implementing CE. A major bottleneck in moving towards CE is the lack of relevant expertise and technical knowledge of the transformation process from linear to circular model (Shahbazi et al., 2016). Awareness and lack of commitment form the top management coupled with the resistance to change are some of the noted barriers. (Agyemang et al., 2018; de Sousa Jabbour et al., 2018; Ilić and Nikolić, 2016; Ferronato et al., 2019; Bekchanov and Mirzabaev, 2018). However, these are considered to be knowledge-based barriers and can be eliminated by organising awareness workshops and training programs emphasising the need for CE. Kirchherr et al., (2018) emphasized the significance of cost and financial barriers which is due to the restructuring of existing infrastructures to suite CE adoption. Lack of resources (Ghisellini et al., 2018), Quality of finished products in CE (Kaminski and Pepin, 2018), Inability of firms to leverage the end-of-life products as raw materials (Murray et al., 2017) are a few notable barriers any firm faces before moving successfully towards CE. To overcome these challenges, managers should invest on identifying the drivers to CE adoption which counter the ill effects of the barriers and lead towards successful CE adoption. The drivers are discussed in the next section.

2.2 Drivers of circular economy

For this paper, an extensive literature review was conducted in Scopus, Science Direct, Web of Science, Emerald, Taylor and Francis, and Springer databases, and all articles published

until December 2019 was considered. Keywords such as 'circular economy', 'CE', and 'drivers' were searched in article titles, abstracts and keywords under topics within the specific search database. A total of 105 articles were located in the search. By adding an additional keyword 'enablers' and rerunning the search algorithm resulted in a total of 134 articles. From the literature reviewed, 18 driver categories (Table 1) were identified.

Table 1. Drivers for CE adoption

1	Government rules and regulation	Hazen et al. (2017); Masi et al. (2018); Maqbool et al. (2020); Mathews and Tan (2011); Salim et al. (2018); Gusmerotti et al. (2019); Ilić and Nikolić (2016); Agyemang et el. (2019); Fedotkina et al. (2019)
2	Awareness about CE	Ilić and Nikolić (2016); Masi et al. (2018); Liu and Bai (2014); Lieder and Rashid (2016); Maqbool et al. (2020); Mathews and Tan (2011); Moktadir et al. (2017); Salim et al. (2018); Xue et al. (2010)
3	Funding availability for CE	Mathews and Tan (2011); Fiksel and Lal (2018); Moktadir et al. (2018); Ilić and Nikolić (2016); Fedotkina et al. (2019);
4	Information on the economic benefits of CE adoption	Neves et al. (2019); Goyal et al. (2018); Bastein et al. (2013); Govindan and Hasanagic (2018); Agyemang et el. (2019)
5	Strategic intent of top management	Moktadir et al. (2018); Siemieniuch et al. (2015); Gusmerotti et al. (2019); Koszewska (2018); Fedotkina et al. (2019); Govindan and Hasanagic (2018); Agyemang et el. (2019)
6	Need for Business resilience and competitive advantage	Mathews and Tan (2011); Moktadir et al. (2018); Koop and van Leeuwen (2017); Rodriguez-Anton et al. (2019); Gusmerotti et al. (2019); Agyemang et el. (2019)
7	Increasing population and urbanisation	Maqbool et al. (2020); Wright et al. (2019); Agyemang et el. (2019); Fedotkina et al. (2019); Ilić and Nikolić (2016); Pringle et al. (2016)
8	Increasing resource consumption and demand for renewable energy	Wu et al. (2017); Maqbool et al. (2020); Gusmerotti et al. (2019); Clark et al. (2016); Schiller et al. (2017); Sun et al. (2017)
9	Cross functional collaboration and partnerships	Moktadir et al. (2018); Agyemang et el. (2019); Zhu et al. (2010); Ilić and Nikolić (2016); Wright et al. (2019);
10	Climate change	Ilić and Nikolić (2016); Pringle et al. (2016); Hazen et al (2017); Clark et al. (2016); Quina et al. (2017)
11	Environmental awareness among consumers	Ilić and Nikolić (2016); Lieder and Rashid (2016); Liu and Bai (2014); Su et al. (2013); Van Eijk (2015);
12	Technological advancements	Mahpour (2018); Su et al. (2013); Salim et al. (2018); Sposato et al. (2017); Ilić and Nikolić (2016); Elia et al. (2017); Lewandowski (2016); Jun and Xiang (2011); Xuan et al. (2011)
13	Resource efficient product design and manufacturing	Ilić and Nikolić (2016); Su et al. (2013); Govindan and Hasanagic (2018); Lieder and Rashid (2016); Gregson et al. (2015)
14	Deteriorating public and animal health	Quina et al. (2017); Ilić and Nikolić (2016); Pringle et al. (2016); Govindan and Hasanagic (2018); Wright et al. (2019); Geng et al. (2012)

15	Reverse logistics infrastructure	Garza-Reyes et al. (2019); Agrawal et al. (2015); Isernia et al. (2019); Bernon et al. (2018); Goyal et al. (2018)
16	Consumer attitude towards refurbished products	Hazen et al. (2017); Liu and Bai (2014); Lakatos et al. (2018); Vehmas et al. (2018); Mashhadi et al. (2019); Cheng and Chou (2018)
17	Social responsibility and ethics	Esken et al. (2018); Daú et al. (2019); Popescu (2018); Fortunati et al. (2020); Pla-Julián and Guevara (2019); Qiao and Qiao (2013)
18	Skill development/employee training	Liu and Bai (2014); Fedotkina et al. (2019); Bechtel et al. (2013); Siemieniuch et al. (2015); Moktadir et al. (2018); Hottle et al. (2015)

Government rules and regulation: Government rules and regulations can ensure radical changes in the way industries operate (Hazen et al., 2017). The Indian government through the Ministry of Environment, Forest and Climate Change has initiated sustainable policies through specific rules on plastics waste management (2016), e-waste management (2106), construction and demolition waste management, including other recycling policies to promote circular economy (Aayog, 2018). Standards are required to identify and verify the level of adoption of circular economy. For example, BIS 8001 standards on CE supported the EU to manage resources for environmental and social benefits. The Chinese government adopted CE as a national policy priority (Masi et al., 2018). But India lacks similar policies and standards for SMEs on CE and NITI Aayog is involved in designing specific schemes and policies to promote CE.

Awareness about the circular economy: An awareness of CE is important to the drive the adoption of circular economy models (Ilić and Nikolić, 2016). The suppliers, consumers, designers, engineers, procurement and production managers are active participants and stakeholders in CE (Masi et al., 2018). Hence, educating the stakeholders along with businesses is important to influence the uptake of CE (Liu and Bai, 2014). Businesses in India are currently not fully informed about the circular economy principles and especially in case of SMEs, there is a need to raise the awareness by embedding CE in educational curriculum, e.g. schools and

professional development programmes, for its successful implementation (Ellen MacArthur Foundation, 2016).

Funding availability for the circular economy: Funding supports organisations move to adopting the CE model (Moktadir et al., 2018). Waste management in developing countries is a particularly challenging issue, and government funding is suggested to address this problem (Fiksel and Lal, 2018). The joint role of the government and private sector has been highlighted to drive innovative funding models (FICCI, 2018), and considerable budgetary allocations have been made to promote CE initiatives (Aayog, 2018). SITRA, a Finnish government innovation fund, has supported exploring circular economy opportunities in India (Ellen MacArthur Foundation, 2016). India could follow the EU 2015 Action Plan for the Circular Economy which establishes a concrete and ambitious program of action, with measures covering the whole cycle: from production and consumption to waste management and the market for secondary raw materials", covering not only legislative efforts but also the funding tools (EC, 2015).

Information on the economic benefits of circular economy adoption: CE has potential to deliver direct and indirect economic benefits (Goyal et al., 2018). The Ellen MacArthur foundation (2016) reported that by adopting CE principles, India could save about 30% of GDP by 2050. FICCI's (2018) 'Circular Economy symposium' reported that India can save half a trillion-dollar worth of GDP by adopting circular economy principles by 2030. Bastein et al., (2013) rightly define CE as "an economic and industrial system based on the reuse of products and raw materials, and the restorative capacity of natural resources". CE minimises value destruction and maximises value creation in the system which can unlock long term revenue through an effective and efficient use of resources (Govindan and Hasanagic, 2018).

Strategic intent of top management: The vision, mission and culture of the firm orient it to the CE model. The change in organisation can be effectively implemented if the senior

management are committed to restructuring firm's policies and practices (Moktadir et al., 2018) which implies that coordination of strategic team with tactical and operations level is vital (Law and Gunasekaran, 2012). Siemieniuch et al. (2015) summarised that leadership and top management commitment are important for the successful adoption of CE. Lack of senior management involvement hampers achieving efforts (Griffiths and Petrick, 2001; Carter and Dresner, 2001) and a holistic implementation framework requires management support and a dedicated approach (Guinipero et al., 2006). Once the top management commits to adopting CE it is a motivation for the organization that the change will boost the organisation's efforts towards its successful adoption (Dubey et al., 2018).

Need for business resilience and competitive advantage: Ellen MacArthur foundation (2013) introduced the notion of resilience and states: "A circular economy is an industrial economy, which has resilience as intention and replaces usage by using. The circular economy is based on closing loops and (where possible, infinitely) extending cycles". With huge uncertainty in demands Indian SMEs aim for resilience and competitive advantages (Aguiñaga et al., 2018) in light of the current rapidly changing market trends and decreased product lifecycles industries (Brand and von Gleich, 2015). The activities associated with CE improves competitiveness of export-oriented sectors in developing countries, for example, practices, such as recycling, reducing and remanufacturing play a role in building resilience while increasing yields. Hence, business resilience and competitive advantage are important drivers.

Increasing population and urbanization: Indian population growth is a key driver for CE adoption (FICCI, 2018). The FICCI report states that 60% of the population will live in urban areas, up from about 30% in 2015. With this growing population, Indian SMEs can cash in by adopting CE principles for smart cities, food and agriculture, mobility etc. as it offers the opportunity to decouple growth from resource requirements. But the increase resource

utilisation due to growing population demands innovative approaches that the CE business models offer. Hence, increasing population and urbanisation are important drivers.

Increasing resource consumption and demand for renewable energy: Increased resource consumption and urbanisation is depleting resources beyond replenishment which places future generation in debt (Yaduvanshi et al., 2016). The higher demand for renewable resources and decoupling economic growth from resource dependency circular economy is the way forward (Wu et al., 2017). The critical resources (e.g. petroleum, plastics, steel, copper, gold, cement, food, fibers and textiles) in India's development are consumed at a higher rate (FICCI, 2018) and the current linear model of economy puts India in a position unlikely to sustain industrial growth (Aayog, 2018). Hence, increasing resource consumption and demand for renewable energy drives the need for the adoption of CE.

Cross functional collaboration and partnerships: Cross functional collaboration and partnerships in businesses impact the performance outcomes (Zhu et al., 2013). Collaboration with government authorities, NGOs and even, consumers will ease the transition from linear to circular economy. Kanda et al. (2016) summarised that public-private partnerships are important in the functioning of large-scale environmental technology. Lee (2010) illustrated how successful inter organisational collaboration was key to reducing the recycling and disposal costs by 35% for Hewlett and Packard, Electrolux, Sony and Braun with support of a common European Recycling Platform. Within sectors, firms can close the material flow loops by engaging effective and efficient partnering with suppliers. For example, Tata sustainability group, in its 2017 report entitled "The Tata group and the SDGs" states that Tata's Jaguar and Land Rover sold waste aluminium from used vehicles back to the supplier company (Novelis) which enabled a possible recovery of around 50,000 tons and supported Novelis to reduce its GHG emissions by 13% in one year. Further, the impact is not limited to only manufacturing

but also extends to its suppliers (Mani et al., 2015). Hence, we argue that collaboration and partnerships are drivers for CE adoption.

Climate change: The recent climate changes due to increased waste production and greenhouse gases emissions deteriorates the quality of life (Change, 2014) and the growing scarcity of resources creates the need for future sustainable economy (EEA, 2012). Environmental pollution and degradation of natural resources are among the prime concerns of India and the agricultural sector has been hit the hardest in recent years (Ellen MacArthur foundation, 2016). In order to address the threat of climate change and associated resource scarcity adopting circular economy principles across businesses is critical (FICCI, 2018). The Ministry of Environment, Forests and Climate Change in 2015 explored the options that circular economy offers to address resource efficiency and utilization (Aayog, 2018) and hence, climate change acts as a driver.

Environmental awareness among consumers: Globally consumers have higher level of knowledge on the environmental impacts of industries (Seuring and Müller, 2008). While the customers' awareness on green concerns forces the manufacturers to adopt environmental practices to deliver green products and services (Ilić and Nikolić, 2016), the inability to deliver green products has a major effect on the firm's reputation and growth (Dubey et al., 2018). Customers are realising the need for conserving the resources for future generations and are willing to pay more for environment friendly product and services (Govindan and Hasanagic, 2018), as a result, the firms involved in sustainable and green manufacturing programs are well received by this new generation of customers (Dubey et al., 2016). More the customer awareness is, higher is the pressure on industries to move towards green approaches (Jia et al., 2015). CE principles provide the base for manufacturing products to use biodegradable resources, thus promoting resource recovery (Liguori and Faraco, 2016). With India now facing an acute resource crunch and in light of the need to green the environment adopting CE is

needed (Ellen MacArthur foundation, 2016). Thus, the environmental awareness of consumers is an external driver for adopting CE.

Technological advancements: The emerging technologies, such as the Internet of Things (IoTs), Blockchain technology (BCT), 3D printing and bio-based materials have led to cleaner production and waste elimination (Geng and Doberstein, 2008). The resulting predictive maintenance using BCT and IoTs has been sensational in tracing the behaviour of products (Apte and Petrovsky, 2016). Technology enables sustainable packaging, effective waste collection and monitoring (Kok et al., 2013) and supports eco-friendly technologies with the potential to contribute to reduce and recycle (Ellen MacArthur foundation, 2016). Researchers suggest that superior technologies and business models can convince linear economic structures to change to the circular approach (Lewandowski, 2016; Jun and Xiang, 2011; Xuan et al., 2011). The significance of green and sustainable activities in businesses has led to cleaner technological advancements (Ning, 2001) which hinder or foster the adoption of CE and, hence, considered a driver.

Resource efficient product design and manufacturing: The finite resources and linear production models lead to resource depletion due to the shorter life cycles of products (Ilić and Nikolić, 2016). The associated environmental consequences call for resource efficient design and resource efficient manufacturing (Su et al., 2013). Researchers have reported that resource efficient product design and manufacturing can positively influence CE adoption (see Su et al., 2013;Ilić and Nikolić, 2016; Lieder and Rashid, 2016; Govindan and Hasanagic, 2018). According to Hislop and Hill (2011) "The circular economy represents a development strategy that maximizes resource efficiency and minimizes waste production, within the context of sustainable economic and social development". Green product development through resource efficient design and manufacturing will enable easier end of life management (Chen, 2001). Improving the efficiency of the resources and waste reduction-oriented manufacturing are the

key elements of circular economy (Govindan and Hasanagic, 2018). Hence, the need for resource efficient product design and manufacturing is an important driver of CE.

Deteriorating public and animal health: Ecological degradation has increased over time (Pringle et al., 2016). Humans and animals are integral part of the ecosystem and due to rapid industrialisation and urbanisation India is facing environmental challenges that endanger the fragile ecosystem (Quina et al., 2017). The growing land fillings and the dumping of wastes into the sea in India affects the quality of soil, air and water thereby affecting the public and animal health (Gandhi, 2015). CE protects public and animal health by minimising pollution and encouraging efficient use of recyclables (Gregson et al., 2015). The concept of CE was addressed in Rio +20 summit as a go-to strategy for saving the earth's ecosystem. Further, circular economy is "one of the important tools which can contribute to eradicating poverty as well as sustained economic growth, enhancing social inclusion, improving human welfare and creating opportunities for employment and decent work for all, while maintaining the healthy functioning of the Earth's ecosystems" (Rio +20, 2012). Hence, deteriorating public and animal health is a driver for CE adoption.

Reverse logistics infrastructure: Getting back the used products from customers is the first step in adapting circular business models, but this requires a well-planned reverse logistics infrastructure. Bhatia et al. (2020) mention that reverse logistics infrastructures are critical for implementing closed-loop supply. Bernon et al., (2019) built an exploratory framework stressing the importance of reverse logistics infrastructures and practices in obtaining circular economy benefits. Agrawal et al., (2015) argued that developing reverse logistics infrastructure is the integral part in collecting used products efficiently for further treatment. Also, Ellen MacArthur Foundation (2016) pointed out that building up a reverse infrastructure, possibly to the point that users have a true 'circular option' for all important product categories is necessary. Hence, reverse logistics infrastructure is a major driver for CE.

Consumer attitude towards refurbished products: Consumer attitude towards used and refurbished products play a vital role in demand creation for circular products. If there is no demand for refurbished products, then the CE model fails miserably. Consumers demand product to function as specified and using a new product gives the psychological satisfaction. Today, many consumers tend to purchase more than what they need and treat the lowest-priced refurbished as disposable (Mashhadi et al., 2019). Vehmas et al., (2018) summarised that the consumer attitude towards buying refurbished apparels has to be changed for the uptake of the CE. Cheng and Chou (2018) studied the role of cultural differences in accepting the circular products in the success of CE by considering European consumers. Promoting the need to circular products and establishing the importance of using can help in creating demand for them. Hence, customer attitude towards circular products is an important driver.

Social responsibility and ethics: The role of social responsibilities and ethics has received greater attention in recent years among researchers. Strong social responsibility on the part of firms and ethical business are parallel with CE initiatives and strategies (Esken et al., 2018). Individual moral beliefs and feeling responsibility for firms' environmental and social impact related negative consequences (Gusmerotti et al., 2019). Daú et al., (2019) analysed the CE transition in health care by building a conceptual framework with the corporate social responsibility mirror. Fortunati et al., (2020), emphasised the parallel between corporate social responsibility and CE in the Cosmetic Industry. Popescu (2018), stressed the role of social responsibility and business ethics in successful adoption of CE model. Hence, social responsibility and ethics are important drivers.

Skill development / employee training: R&D support, education and training create general awareness and develop skills base, and are necessary for adopting CE models. Fedotkina et al., (2019) summarised the importance of skills development as a driver for adoption of CE in Russia's waste management systems. For example, remanufacturing and recycling require

skilled engineers or employees with technical knowledge and advanced expertise. Developing the firms' own knowledge base via training will greatly affect the efficient adoption of the CE model. Hence, preparing the work force for the shift from linear to circular model is an important driver in CE adoption.

3. Modelling the drivers to support SMEs in India to adopt circular economy

This paper uses an TISM approach to model the drivers for the adoption of CE in Indian SMEs followed by a MICMAC analysis to identify the driving, dependent and linking elements in the TISM model. Total Interpretive Structural Modeling (TISM) is a novel qualitative method to develop a strategic framework which explains CE adoption phenomena. TISM supports developing a contextual relationship-based performance model for analysing the drivers to the adoption of CE in Indian SMEs context, by allowing researchers to understand the interactions between the driving elements (Dubey et al., 2017). Sushil (2012) argues that TISM a systems theory-based model supports better decision making which is missing in other structural models like of Artificial Neural Networking (ANN) and Structural equation Modeling (SEM). TISM offers not only the interpretive logic of relationships within the system but also explains the causality of each link in the resulting hierarchical model. The steps of TISM are adopted from Jayalakshmi and Pramod (2015) and described in the following sub sections below in figure 2.

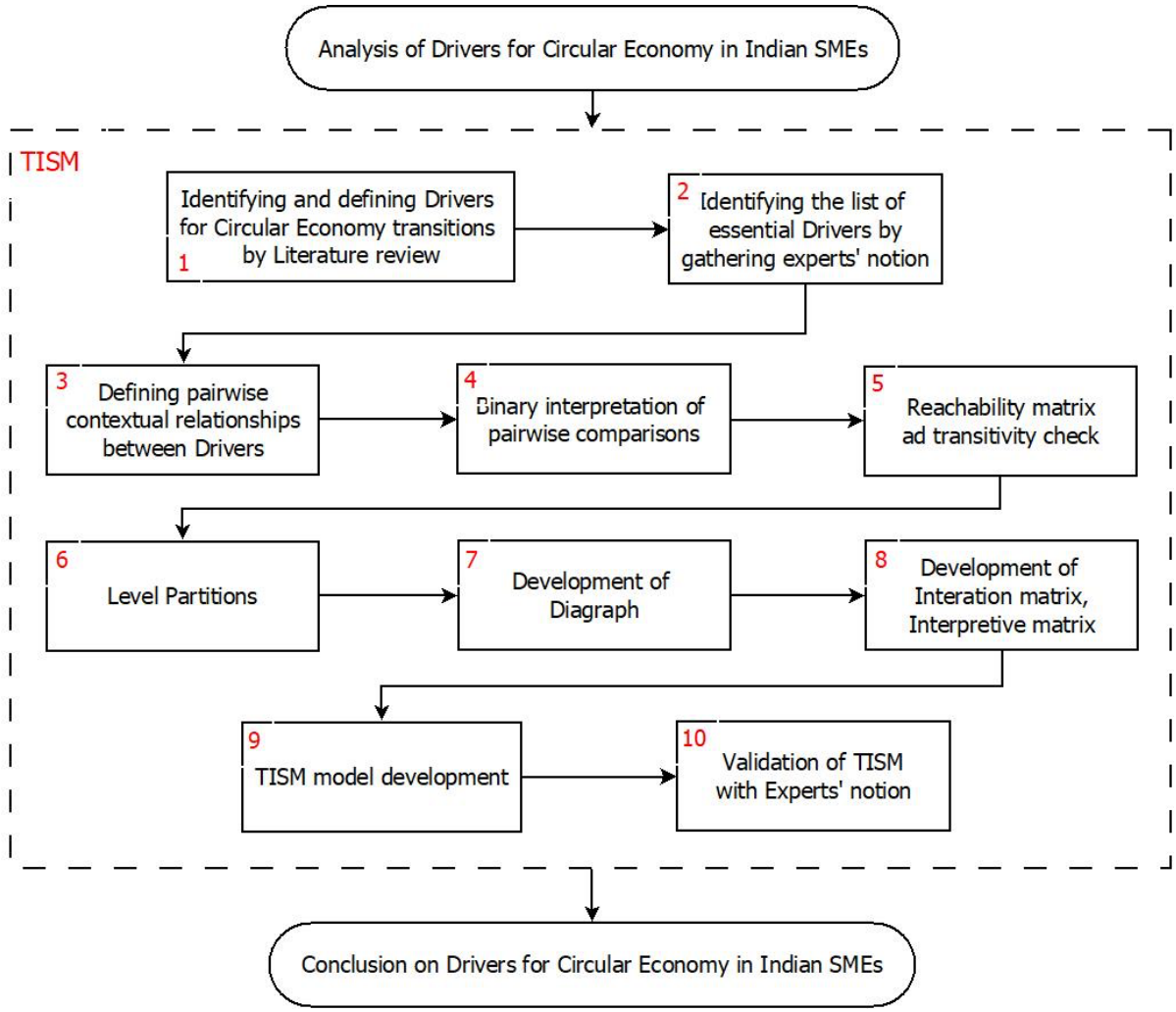

Figure 2. Solution Methodology

3.1 Identification of essential drivers through questionnaire survey

The 18 drivers for adoption of circular economy, identified from the literature review, were discussed with experts from SMEs in Tamil Nadu and the validity of drivers was verified with experts. The experts were selected from four industrial sectors namely, Textile, Automobile, Electronics, and Tourism. In addition, academics with expert knowledge on the Indian economy were also invited to participate. All respondents had managerial experience and prior work experience of more than five years in the relevant sectors. The demographics of the experts is provided in the Table 2.

Table 2. Demography of respondents of the research

Type of SME	Number of respondents	Percentage
Textile	13	16.66
Automobile	21	26.9

Electronics	14	17.94
Tourism	12	15.38
Education	18	23.07
Total	78	100

After initial meetings the list of drivers was revised to 10. This process involved voting and critical reasoning of how these elements drive circular economy adoption. i.e., the expert votes 'yes' to state validate the driver or votes 'no' and provides his/her reason for not considering any particular element as a driver for CE adoption in Indian SMEs. Once the voting was completed the central tendency of respondents was derived from the median of the responses. Further, discussions with experts revealed that *"Information on economic benefits of circular economy* is more similar to the *awareness about circular economy*." Hence these two were integrated as a single driver. Drivers, such as *Skill development / employee training* and *Cross functional collaboration and partnerships* were identified by the experts as more of CE practices than drivers. Hence, we decided not to consider these two for further analysis. After further discussions, the experts clarified that drivers *Climate change* and *Deteriorating public and animal health* are global issues which led to the development of ideology of CE and, hence, in our study which analyzes the adoption drivers from the firms' perspective, these two drivers might be eliminated from further analysis. Also, several experts argued that Reverse logistics Infrastructure is an enabler for effective CE model, and not a relevant driver for SMEs to adopt CE models. Finally, the experts suggested that *Government rules and regulations*, i.e. initiating the Circular Economy Mission and *Strategic intent of the top management* are reasons that explain the uptake of CE adoption by SMEs and that other drivers eventually follow parent drivers. From the above discussions and 'yes' or 'no' voting, we eliminated this driver and the remaining 10 drivers (out of the 18) as presented in the table 3 below have been considered for developing the TISM model.

Table 3. List of essential drivers for CE adoption in Indian SMEs

Notion	Driving Elements
D1	Awareness about circular economy
D2	Funding availability for the circular economy

D3	Need for business resilience and competitive advantage
D4	Increasing population and urbanization
D5	Increasing resource consumption
D6	Environmental awareness among consumers
D7	Technological advancements
D8	Resource efficient product design and manufacturing
D9	Consumer attitude towards refurbished products
D10	Social responsibility and ethics

These 10 drivers were put in an interpretive knowledge base framework to capture the contextual relationships between them with support of expert opinions. The sampling method employed here is the purposive sampling method where in the experts were identified and targeted so that they will the respondents who are capable of defining the relationships between the CE drivers identified. The experts had to check 90 paired relationships which was time consuming so only 16 respondents gave their consent (from targeted 78). Though the number of expected responses were low, considering the quality of the experts in terms of their experience in number of years at managerial levels in their institutions and their knowledge in CE transitions and contemporary policies of the Indian government on CE adoption they would ideally represent the exact view of the population and with the existing time constraint decision was made to proceed further with these available responses. These experts were provided a general awareness session of the shortlisted 10 drivers by explaining the relevance of each driving element in the context of Indian SMEs.

3.2 Development of Interpretive knowledge base

After the general awareness session with the experts, the next step was to define the contextual relationship between the shortlisted drivers. Hence, identified experts were interviewed personally and were questioned on the influence of each driving element on the other. With further brainstorming sessions, the rationale behind the influential relation of one driver over other was captured. For instance, while comparing any pair of driver elements if the respondent believes there exist an influential relationship the respondent is asked to mark ‘yes’ and the reason for the influence as believed by the respondent is required to be entered if any. Once all

the responses from the respondents are accumulated, the stated reasons are argued and taken into further discussions to access the validity of the response. Once validate the final response is used to develop the knowledgebase in the form of the table 4 below.

Table 4.The interpretive logic knowledge base

SN	Notations of Barriers under comparison	Paired comparison	Any relationship exists?	Brief explanation of relationship if any
1	D1-D2	Awareness about CE will influence Funding availability for the circular economy	No	-
2	D2-D1	Funding availability for the circular economy will influence awareness of CE	Yes	SMEs look into aspects of CE to take advantage of funding opportunities
.	.	.	.	.
.	.	.	.	.
90	D10-D9	Social responsibility and ethics will influence consumer attitude towards refurbished products	No	-

3.3 Binary interpretation for developing Initial reachability matrix

To develop the contextual relationships with TISM model i.e., the 'yes' and 'no' in the interpretive logic knowledgebase were converted into '1' and '0', respectively to establish the initial reachability matrix. In our study, a 10 x 10 matrix was developed based on the 90 pairwise comparison. The comparisons were represented in the form of a matrix with each element except the diagonal elements carrying binary values '1' or '0'. The value '1' was given in the cells if the logic knowledge base shows any existing relationship (direct relationship) between the compared barriers, otherwise value '0' is entered (Dubey et al., 2015). The table 5 below presents the initial reachability matrix.

Table 5. Initial Reachability matrix

Notion	Driving Elements	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
D1	Awareness about circular economy	-	0	0	0	0	0	0	0	0	0
D2	Funding availability for the circular economy	1	-	0	0	0	0	1	1	0	0
D3	Need for business resilience and competitive advantage	0	0	-	0	0	0	1	1	0	0
D4	Increasing population and urbanization	0	0	0	-	1	0	0	0	0	0
D5	Increasing resource consumption	0	0	1	0	-	0	0	1	0	0
D6	Environmental awareness among consumers	0	0	0	0	0	-	0	1	1	1

D7	Technological advancements	0	0	1	0	0	0	-	1	0	0
D8	Resource efficient product design and manufacturing	0	0	0	0	0	0	1	-	0	0
D9	Consumer attitude towards refurbished products	0	0	0	0	0	0	1	0	-	0
D10	Social responsibility and ethics	0	0	0	0	0	0	0	1	0	-

3.4 Final Reachability Matrix and Check for Transitivity

After developing the initial reachability matrix the final reachability matrix was constructed by considering the transitivity rule, i.e., if a variable 'A' is related to 'B' and 'B' is related to 'C', then 'A' is necessarily related to 'C'. While identifying the transitive relation between the driving elements the reasons behind the transitive relationship were analysed through extensive discussions with experts. The final reachability matrix is presented in Table 6 below. The transitive links identified are denoted as '1*'.

Table 6. Final Reachability Matrix

Notion	Driving Elements	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
D1	Awareness about circular economy	-	0	*1**	0	0	0	1	*1**	0	1
D2	Funding availability for the circular economy	1	-	*1**	0	0	0	1	1	0	0
D3	Need for business resilience and competitive advantage	0	0	-	0	0	0	1	1	0	0
D4	Increasing population and urbanisation	0	0	*1**	-	1	0	0	*1**	0	0
D5	Increasing resource consumption	0	0	1	0	-	0	*1**	1	0	0
D6	Environmental awareness among consumers	0	0	0	0	0	-	*1**	1	1	1
D7	Technological advancements	0	0	1	0	0	0	-	1	0	0
D8	Resource efficient product design and manufacturing	0	0	*1**	0	0	0	1	-	0	0
D9	Consumer attitude towards refurbished products	0	0	*1**	0	0	0	1	*1**	-	0
D10	Social responsibility and ethics	0	0	0	0	0	0	*1**	1	0	-

3.5 Level partitions

The reachability, antecedent and the interaction sets for each driving element are obtained from the final reachability matrix (Warfield, 1976). The reachability set of any element consists of itself and the other driving elements which it may influence/help to achieve. The antecedent set of any element consists of itself and other driving elements which may influence/help in achieving it (Muduli et al., 2013). The common elements in reachability set and antecedents set form the intersection set. If the reachability and intersection sets are same for any driving elements, then those elements are assigned Level 1. After this these elements are discarded

from the remaining elements which marks the completion of iteration 1. The iterations are continued until all the elements are at assigned levels. Table 7 shows the 10 drivers partitioned into 5 levels. It is observed that the driving elements are: 'D4' – Increasing population and urbanisation formed the base (level 5) of the ISM model followed by 'D2' – Funding availability for SMEs adopting CE and 'D5' – Increasing resource consumption in level 4. This suggests that these drivers play a key role in supporting the adoption of CE by Indian SMEs.

Table 7. Level partition of drivers for CE adoption in Indian SMEs

Driving Elements	Notion	Reachability Set	Antecedent Set	Intersection set	Level
Awareness about circular economy	D1	1,3,7,8,10	1,2	1	iii
Funding availability for the circular economy	D2	1,2,3,7,8	2	2	iv
Need for business resilience and competitive advantage	D3	3,7,8	1,2,3,4,5,7,8,9	3,7,8	i
Increasing population and urbanisation	D4	3,4,5,8	4	4	v
Increasing resource consumption	D5	1,5,7,8	4,5	5	iv
Environmental awareness among consumers	D6	6,7,8,9,10	6	6	iii
Technological advancements	D7	3,7,8	1,2,3,5,6,7,8,9,10	3,7,8	i
Resource efficient product design and manufacturing	D8	3,7,8	1,2,3,4,5,6,7,8,9,10	3,7,8	i
Consumer attitude towards refurbished products	D9	3,7,8,9	6,9	9	ii
Social responsibility and ethics	D10	7,8,10	1,6,9,10	10	ii

3.6 Development of Diagraph

A structural model is generated from the level partitions. The hierarchy of each driving element is based on the level partitions obtained. The diagraph is formed after removing the transitive links and depicting the nodes by element statements. To begin with, level 1 elements form the topmost position in the model and other elements in the subsequent levels are placed below to obtain a 5-level model as shown in Figure 3 below. Here all the links are depicted. However, we further analyse whether all the links derived from final reachability matrix exist in reality.

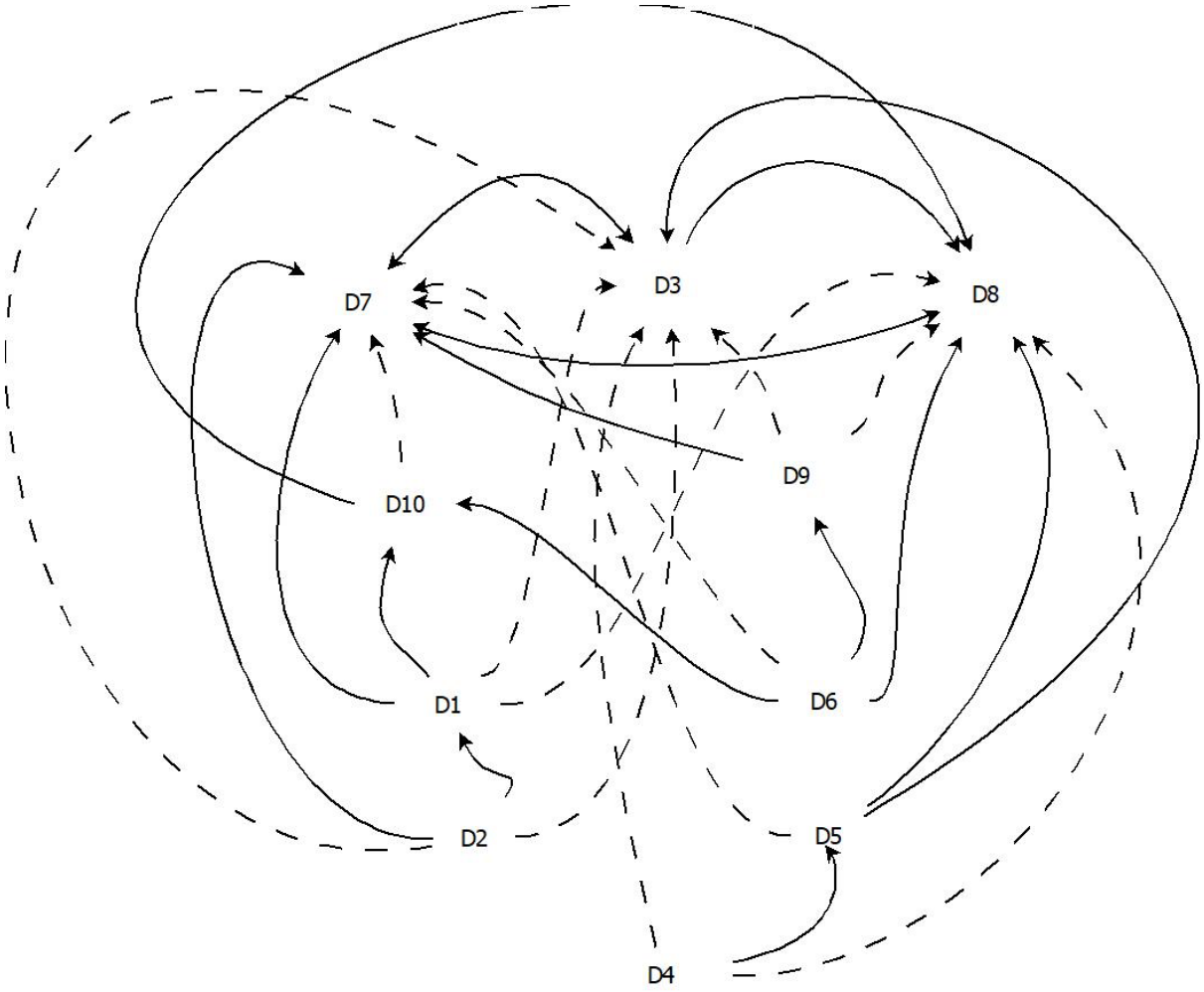

Figure 3. Digraph showing both direct and transitive links

It is observed that *Increasing population & Urbanisation (D4), Increasing resource consumption (D5) and Funding availability for CE (D2)* are significant drivers in CE adoption in Indian SMEs. Drivers, such as *Resource efficient product design (D8), Technological advancements* (D7) and *Need for business resilience & competitive advantage (D3),* occupy the top level in the developed diagraph and are the dependent ones.

3.7 Interaction matrix and Interpretive matrix

The developed diagraph is inputted into a binary interaction matrix by translating all represented interactions as 1 and the rest of the cells are void of entry (Dubey et al., 2015; Jayalakshmi and Pramod, 2015) that form the interaction matrix for our study. Based on the interaction matrix and the entries in logic knowledge base, we develop a 10 x 10 interpretive

matrix with entries. Table 7 and 8 represent the interaction matrix and interpretive matrix, respectively.

Table 7 Interaction Matrix

Notion	Driving Elements	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
D1	Awareness about circular economy	-	0	*1**	0	0	0	1	0	0	1
D2	Funding availability for the circular economy	1	-	*1**	0	0	0	1	0	0	0
D3	Need for business resilience and competitive advantage	0	0	-	0	0	0	1	1	0	0
D4	Increasing population and urbanisation	0	0	*1**	-	1	0	0	*1**	0	0
D5	Increasing resource consumption	0	0	1	0	-	0	0	1	0	0
D6	Environmental awareness among consumers	0	0	0	0	0	-	0	1	1	1
D7	Technological advancements	0	0	1	0	0	0	-	0	0	0
D8	Resource efficient product design and manufacturing	0	0	0	0	0	0	0	-	0	0
D9	Consumer attitude towards refurbished products	0	0	*1**	0	0	0	1	*1**	-	0
D10	Social responsibility and ethics	0	0	0	0	0	0	0	1	0	-

D1	Awareness about circular economy	-	0	*advancements for building resilience & competitive advantage*	0	0	0	CE influences technological advancements	
D2	Funding availability for the circular economy	Funding availability for SMEs creates awareness about CE	-	*Newer technologies help in building resilience and competitive advantage*	0	0	0	Funding availability influences new technological evolutions	
D3	Need for business resilience and competitive advantage	0	0	-	0	0	0	Need triggers birth of new technologies	Need f compe influ effic m
D4	Increasing population and urbanisation	0	0	*Increased resource consumption due to increase in population triggers the need for resilience and competitiveness*	-	increase in population influence increased resource consumption	0	0	*Consu reso reso m*
D5	Increasing resource consumption	0	0	Scarcity of resources triggers need for resilient business	0	-	0	0	Increa trig effic m
D6	Environmental awareness among consumers	0	0	0	0	0	-	0	Awa consu to wo
D7	Technological advancements	0	0	Technological advances influence the need for building resilience and competetive advantage	0	0	0	-	
D8	Resource efficient product design and manufacturing	0	0	0	0	0	0	0	
D9	Consumer attitude towards refurbished products	0	0	*Consumer attitude is positive when newer technologies comes in and thus influences building resilience and competetive advantage*	0	0	0	Positive attitude of consumers towards refurbished products lead to related technological advancements	*Te adva reso m*
D10	Social responsibility and ethics	0	0	0	0	0	0	0	Socia and e trig effic m

3.8 TISM model

The TISM model is developed by portraying the information in the interaction matrix over the developed diagraph (Dubey et al., 2015; Jayalakshmi and Pramod, 2015), this is depicted in Figure 4. The continuous line represents direct relationship and the dashed lined is the indirect relationship between the driver elements. In the developed TISM model one can see that there is considerable reduction in the total number of links when compared to that of the initial diagraph derived. Several indirect relations may exist, but these relations are identified by transitivity check. Here the transitive relations obtained by using the transitivity rule are analysed with the same experts and based on their opinion the explanation for the transitive links are derived and the logic base is updated. Not all the transitive links are effective and hence based on the experts' opinions the ineffective transitive links are eliminated (Dubey et al. 2015; Jayalakshmi and Pramod 2015). This is one of the major upgrades that a TISM model provides. In regular Interpretive Structural Modelling the transitive relations are formed based just on the transitivity rule but in case of TISM the logic behind the transitivity is examined and the effective links alone are considered for further study. This is the advantage of the TISM methodology which simplifies complex models and provides decision makers with effective linkages.

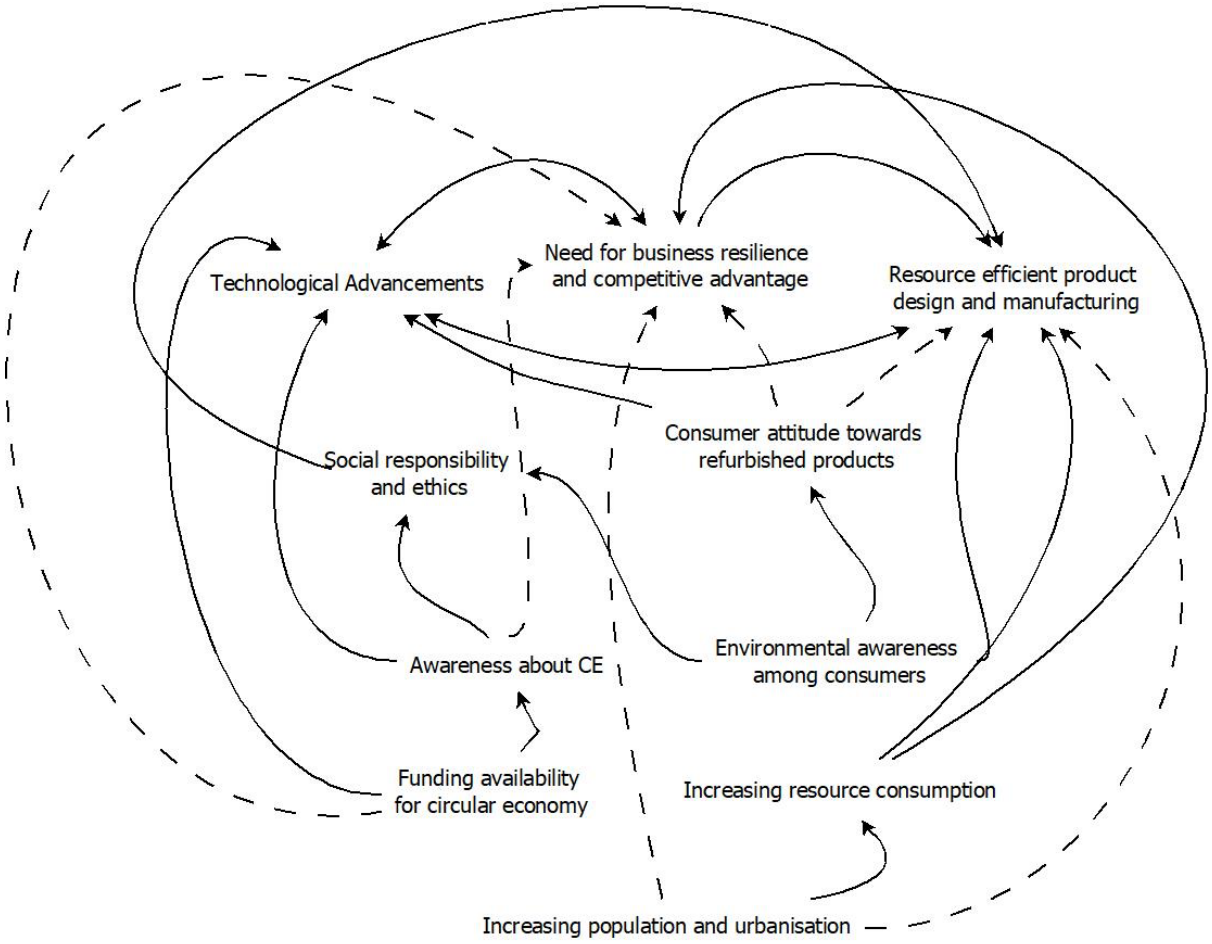

Figure 4: TISM model

3.9 Validation of TISM

The developed TISM model is an outcome of only 16 responses and reason behind the low number of responses has been that every expert had to put in more time to analyse and gives us the information on all 10 x 9 = 90 possible relationship between the 10 driver elements. However, the TISM model developed now has considerable low number of paired relationships and this provides an opportunity to validate these meaningful relationship links with a larger number of respondents. Hence as proposed by Jayalakshmi and Pramod (2015), the same group of experts was contacted and this time a larger group of experts (39 experts) assessed the developed TISM model. Personal interviews were conducted with the experts and discussion all 23 links in the TISM model were discussed in light on bring out the rationale behind the influential relationship of one driver over the other. The median of responses was considered to whether consider the link or not. Out of 23 links the 5 particular linkages received a voting count lesser than median value and hence further discussions were held with the experts to find the rationale behind that. Below we present the summary of discussion to provide the rationale behind rejection of 5 links.

First, the link depicting that the funding availability for CE (D2) influencing the need for business resilience and competitive advantage (D3) was denied with the reason being, the experts believed that SMEs in India were more dependent on the subcontract from the tier 1 or tier 2 suppliers and they are looking at the low-cost production strategy for their business resilience. Also, they gain competitive edge over other SMEs by adopting aggressive agile strategies and funding availability for CE had no link in building resilient and competitive business. Second, the influence of awareness on CE concepts (D1) over Need for business resilience and competitive advantage was denied. This was because the experts made clear that the need for resilient business in Indian SMEs is mainly triggered by the huge number of competitors in the same market. Moreover, India has the highest number of manufacturing

SMEs and the awareness on CE is widespread they lack efficient reverse logistics network and also the lack of demand for refurbished/repaired/reused products hinders their CE adoption.

Third, the transitive link between Consumers' attitude towards refurbished products (D9) and Need for business resilience and competitive advantage (D3) was rejected by the experts. While examining the model, the element providing the transitive relation was Technological advancement driver (D7). The experts rejected this link stating that the Indian SMEs were still functioning with only aged machineries and they do not adapt to technological changes mush easier like bigger firms. Moreover, the discussion resulted in establishing that logically consumers' change in attitude or positive attitude towards refurbished products is minimal and not to the scale of triggering the need for business resilience. This was because, the experts emphasised the fact that Indian SMEs were looking for business resilience and competitive advantage by only engaging in long-term partnerships with the respective firms and not from change in customer attitude. Fourth, the transitive link between Consumers' attitude towards refurbished products and Resource efficient product design and manufacturing is rejected as the experts believed that scarcity and the increasing costs of virgin materials resource had more to do with the resource efficient product design and manufacturing than consumers' attitude. Finally, the fifth link to be rejected is the transitive influence of Increase in population (D5) over the Resource efficient product design and manufacturing (D9). As far Indian population and SMEs are concerned the market scenario was more of a push scenario and also the increased population and the associated urbanisation has only led to increase in use of resources available. However, the resource efficiency thinking is lagging in SMEs as they function basically on make to order strategy and do not get involve in design phase with the firms.

Hence, our final validated TISM model with only effective links is presented in figure 5 below.

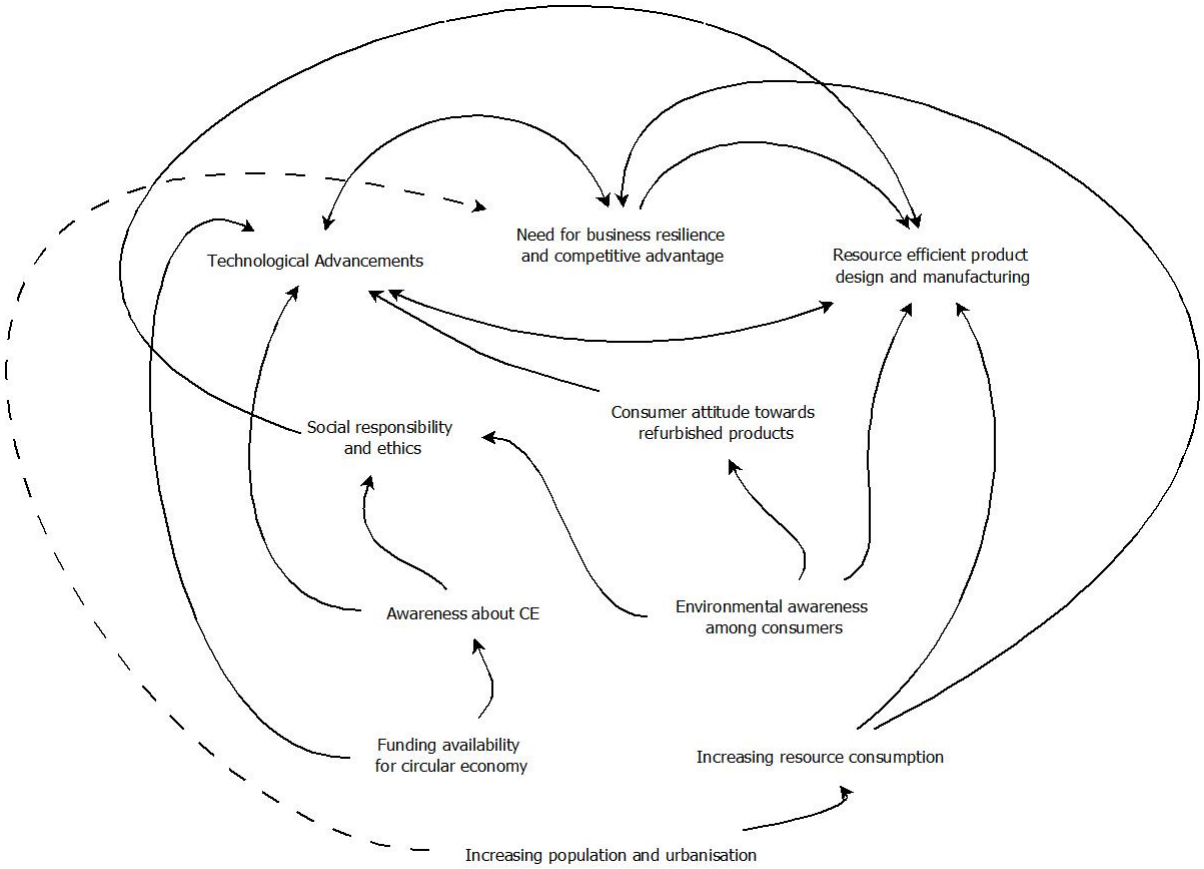

Figure 5. Validated TISM model of Drivers for CE adoption in Indian SMEs

4. Discussion

Figure 5 presents that the five-level TISM model. The ten driver elements are listed at different levels based on their influence on the other drivers. Among the 10 drivers considered only three are found to occupy top level in the hierarchy. The drivers namely, D7 – Technological advancements, D3 – Need for business resilience and competitive advantage and D8 – Resource efficient product design and manufacturing occupy level 1 in hierarchy. These are the drivers which have least influence over the other drivers in the system and are incapable of driving the system on their own. Practically these are the ones which are required to drive CE adoption but are dependent on the other drivers. The discussion with experts suggests that though technological advancements play a major role in repair and refurbishing for CE, but do not drive the idea of CE. As far as D3 – Need for business resilience and competitive advantage driver is concerned, this can influence newer technological advances (D7) and resource

efficient product design and manufacturing (D8). But these drivers are at the same level. Beyond these other driver cannot be influenced due to lower influential power. Experts also confirmed that D3- Need for business resilience and competitive advantage is in any given scenario but in light of promoting CE adoption in Indian SMEs these have very little effect compared to the other drivers. The same argument applied to the third driver in level one, i.e. D8 – Resource efficient product design and manufacturing.

Level-2 consist of two driver elements namely D10 – Social responsibility and Ethics and D9 – Consumer attitude towards refurbished products. These are the linkage drivers which play a crucial role in holding up the entire system along with the level-3 driver Awareness about CE (D1) and Environmental awareness among consumers (D6). These are the most important drivers of the system because they provide the linkage between the driving and dependent elements in the system. Experts summarised that the awareness about CE concepts and environmental awareness among consumers influence consumers' attitude towards refurbished products. Once the consumers and SMEs are aware of CE concepts and its environmental impact their social responsibility and ethical concern kicks in consumers start trying out refurbished products.

Lower hierarchical driving elements D2 – Funding availability for circular economy and D5 - Increasing resource consumption occupy the level-4 and the bottom most level in the hierarchy i.e., the level 5 consists the most influential driver in the system. In our case the driver D4- Increasing population and urbanisation is the most influential of all drivers. The increase in population has not only depleted the available resources but has also increased the rate of consumption as evident from the report from Indian Bureau of Mines (2016). With rapid urbanisation and development of smart cities in India the population is gearing to sharing economy and the regulatory bodies have imposed stringent regulations on resource consumption and recycling, hence a major role in driving the CE adoption in SMEs . The level-

4 drivers funding availability for CE and Increasing resource consumption also have a major influence. Funding availability actually puts CE concept in focus of SMEs' management and triggers the top level to commit to adopting the CE concepts in their organisations as a counter measure to overcome the increasing resources scarcity. Technically, the drivers at the bottom of the hierarchy are capable of driving the entire system positively by pushing the other drivers to achieve the overall goals of the system (Jia et al., 2015). Hence, these are critical and influential and can act as vital force in achieving the other drivers and thus, should be treated on the highest with top priority when adopting CE in SMEs in Tamil Nadu.

5. Conclusion and recommendations

This paper develops a contextual relationship based on the structural model using the TISM approach and explains the interactions between various drivers of circular economy in SMEs in the Indian state of Tamil Nadu. Analysing the driving elements for the adoption of CE is important to achieve long-term economic and ecological sustainability. The TISM model explains the dynamic interactions between the drivers and highlight the transitive linkages between the different drivers to achieve the desired levels in hierarchy. The results provide suggestions on how the CE can be successfully adopted by Indian SMEs located in Tamil Nadu. Increasing population and urbanisation (D4), Funding availability for CE (D2) and Increasing resource consumption (D5) are the most important and influential drivers in creating Awareness about CE (D1) and Environmental awareness among consumers (D6). These potentially trigger the social and ethical concerns among SMEs (D10) and create a positive feel on refurbished products among consumers (D9) which lead to Technological advancements (D7) to enable CE which triggers the need for business resilience & competitive advantage (D3) in today's market and enables the resource efficient product design and manufacturing to maximize the life of resource in the CE model.

6. Limitations and future recommendations

The TISM model developed in this study identifies the drivers for the adoption of CE by Indian SMEs in Tamil Nadu. A limitation is that the impact is analysed subjectively and lacks a mathematical quantification. The bias may exist because the relations among the elements are established depending on the respondent's knowledge and familiarity with the firm, its operations, and the industry. This may impact the final model developed for the analysis. Furthermore, in TISM no weights are associated with the variables to give them any relative importance. Techniques, such as Structural Equation Modelling and Analytic Network Process, can be used in future to validate the model. Gray and Fuzzy theories can also be used to overcome the drawback of limited number of responses and consider the fuzziness of respondents. Grey weights-based MICMAC analysis can be incorporated to include the priority and experience of the respondents. In addition, Decision Making Trial and Evaluation Laboratory (DEMATEL) can be used to identify the dominant practices and a hybrid technique like the DEMATEL based Analytic Network Process (D-ANP) can be used to develop the causal effect-based model of practices to enable quantification of the dominance of practices.

Appendix I

Please answer the survey to the best of your knowledge. Please provide "Y" if the drivers practically help in moving towards CE. The last column on the right is provided for you to comment on the underlying reasons. We encourage you to consider a range of plausible scenarios and factors (i.e., environmental, financial, military, political, technological, etc.) when providing your answers.

Notion	Driving Elements	Yes / No	Rationale
D1	Awareness about circular economy		
D2	Funding availability for the circular economy		
D3	Need for business resilience and competitive advantage		
D4	Increasing population and urbanisation		
D5	Increasing resource consumption		
D6	Environmental awareness among consumers		
D7	Technological advancements		
D8	Resource efficient product design and manufacturing		
D9	Consumer attitude towards refurbished products		
D10	Social responsibility and ethics		

Please provide your views / comments on the relationship diagram developed between the identified drivers. Also provide the information on whether the individual drivers have any influence on the other driving elements. If Yes please list out the influenced driver(s) on the rightmost column for each driver. Also provide the rationale behind the influence.

Notion	Driving Elements	Influenced driver(s)	Rationale
D1	Awareness about circular economy		
D2	Funding availability for the circular economy		
D3	Need for business resilience and competitive advantage		
D4	Increasing population and urbanisation		
D5	Increasing resource consumption		
D6	Environmental awareness among consumers		
D7	Technological advancements		
D8	Resource efficient product design and manufacturing		
D9	Consumer attitude towards refurbished products		
D10	Social responsibility and ethics		

This section is provided for you to list out any barriers other than the listed ones in this survey that you feel to play a major role in adoption of circular economy. A space is also provided for you to comment on the underlying reasons that you believe for them to be a driving force behind the CE adoption process.

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