Smart circular supply chains to achieving SDGs for post-pandemic preparedness

Yasanur Kayikci
Department of Industrial Engineering, Turkish-German University, Istanbul, Turkey
Yigit Kazancoglu, Cisem Lafci and Nazlican Gozacan-Chase
Department of Logistics Management, Yasar University, Izmir, Turkey, and
Sachin Kumar Mangla
Operations Management, Jindal Global Business School, Sonipat, India

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Abstract

Purpose – The coronavirus disease 2019 (COVID-19) pandemic created heavy pressure on firms, by increasing the challenges and disruptions that they have to deal with on being sustainable. For this purpose, it is aimed to reveal the role of the smart circular supply chain (SCSC) and its enablers towards achieving Sustainable Development Goals (SDGs) for post-pandemic preparedness.

Design/methodology/approach – Total interpretive structural modelling and Matrice d'Impacts Croises Multipication Applique' a un Classement (MICMAC) have been applied to analyse the SCSC enablers which are supported by the natural-based resource view in Turkey's food industry. In this context, industry experts working in the food supply chain (meat sector) and academics came together to interpret the result and discuss the enablers that the supply chain experienced during the pandemic for creating a realistic framework for post-pandemic preparedness.

Findings – The results of this study show that "governmental support" and "top management involvement" are the enablers that have the most driving power on other enablers, however, none of them depend on any other enablers.

Originality/value – The identification of the impact and role of enablers in achieving SDGs by combining smart and circular capabilities in the supply chain for the post-pandemic.

Keywords Circular economy, Industry 4.0, Smart circular supply chain, Sustainable development goals, Total interpretive structural modelling, Natural resource-based review

Paper type Research paper

1. Introduction

Global supply chains struggled to meet product demand due to their fragility and lack of organizational resilience with the onset of the pandemic (Sarkis, 2020). Thus, the impact of disruptions, caused by chaos and resonance, spread over global networks as demand and supply fluctuations (Guan *et al.*, 2020). The main reason underneath of these failures in the global supply chain is resulting from the lack of flexibility, visibility and resilience (Bag *et al.*, 2021; Jiang *et al.*, 2016; Kouedeu *et al.*, 2014). Furthermore, the ongoing pandemic has brought the world to a still stand, slowing the success or adoption of the Sustainable Development Goals (SDGs) (Gulseven et al., 2020). To address these types of challenges in global sustainable development, the United Nations, an international society, adopted the 17 SDGs in September 2015 (Modgil *et al.*, 2020; Leal Filho *et al.*, 2019; Chapman and Shigetomi, 2018; Szabo *et al.*, 2016). Zimon *et al.* (2020) suggested the SDGs as an umbrella framework for sustainable supply chain (SSC)

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practices, extending the intertwined goals of economic, environmental and social pillars. The SSC practices can be defined as sustainable supplier management, sustainable operations and risk management, and lastly, pressure and incentive management (Zimon *et al.*, 2020). With these practices, SDGs can be maintained via the broader usage of circular economy (CE) principles throughout the area and economy (Kayikci *et al.*, 2021; Balanay and Halog, 2016). As a result, coronavirus disease 2019 (COVID-19) may open up new research opportunities into SSC processes (Sarkis, 2020) by addressing the possible importance of the idea and reality of digital sustainability (Pan and Zhang, 2020) to achieve the SDGs for post-pandemic preparedness.

A post-pandemic preparedness is necessary due to the impacts of COVID-19. Global financial markets crumbled in the first quarter of 2020, because of — or expedited by — a global economic shutdown, anxiety and ambiguity regarding the future (Leal Filho *et al.*, 2020). In detail, Leal Filho *et al.* (2020) stated that an online research about impact and COVID-19 gives 4,280,000,000 results, and 68% indicates the impacts on businesses, economy and sectors including food, tourism, aviation etc. Accordingly, these impacts are also reflected on SDGs such as SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-Being), SDG 4 (Quality Education), SDG 5 (Gender Quality), SDG 8 (Decent Work and Economic Growth), SDG 10 (Reduced Inequalities) and SDG 16 (Peace, Justice and Strong Institutions) (Leal Filho *et al.*, 2020). The consequences of the COVID-19 pandemic reveal the need for sustainability as well as transforming the way of doing global business during the era of digitalization; therefore, smart circular supply chain (SCSC) could have a larger role in tackling the UN's SDG agenda (Pan and Zhang, 2020). Since CE activities and SDGs have such a special connection (Kristoffersen *et al.*, 2020; Schroeder *et al.*, 2019), and Industry 4.0 (I4.0) and sustainability issues are inseparably linked (Luthra *et al.*, 2020; Müller *et al.*, 2018). In detail, I4.0 provides smartness with the present rise of digitization and data interchange in manufacturing systems, such as cloud computing, the Internet of things, cyber-physical systems, etc. Furthermore, instead of a linear "in and out" economy, circular supply chains (CSCs) are progressively adopting to close the loop of their supply chains to save expenses, loss and waste. And with the combination of these two concepts, SCSC is formed. Thus, SCSC can eliminate resource loops for materials (e.g. raw materials, medical supplies, etc.) to mitigate shortages caused by COVID-19 (Nandi *et al.*, 2020) through encouraging smart circular practices with technical advances and strategies for long-term supply chain sustainability and overall supply chain resilience (Bag *et al.*, 2020; Golan *et al.*, 2020). Furthermore, SCSC is seen as a potential driver of circularity, thanks to smart technologies that digitalization allows for efficient energy management, optimized routes and melioration of logistics resources (Antikainen *et al.*, 2018). In addition, smartness enables the transition to more circularity by allowing data transparency regarding resource use and facilitating the management of product life cycles (Antikainen *et al.*, 2018; Kagermann, 2015). As a result, the incorporation of smart technology and materials will help in the growth of the appropriate infrastructure for integrating feedback-rich systems over the product lifespan, as well as encourage knowledge transparency and process circularity (MacArthur *et al.*, 2015) for the post-pandemic preparedness.

Natural resource-based view (NRBV) can be a great enabler for SCSC in terms of SDGs due to the theory of competitive advantage based upon the firm's relationship with the natural environment (Hart, 1995). SCSC and NRBV perform together to provide important contributions to environmental concerns such as the current pandemic, which poses challenges to the SDGs (Leal Filho *et al.*, 2020). NRBV is one of the most commonly used organizational theories for explaining dynamic processes and supply chain management (Bowen *et al.*, 2001) with its three interconnected strategies: pollution prevention, product stewardship and sustainable development (Hart, 1995). NRBV explores a company's resources and capabilities to gain a long-term competitive advantage (Barney, 1991). Having an organization's resources stand out or outperform those of its competitors will be a competitive advantage as long as the resource requirements are perfectly matched with environmental necessities and business opportunities (Andrews, 1971).

As explained in the paragraphs above, the enabler effect of NRBV on SCSC and its strategic effect on achieving SDGs are visible. Moreover, the interconnection of NRBV and SCSC may have great potential especially under the condition of the dynamic complexities of post-pandemic preparedness. However, to the best of our knowledge, there is no such study in the literature that reveals a research gap. The main motivation underlying the following research questions (RQs) is a need for defining the role of SCSC and its enablers for achieving SDGs on a theoretical and practical basis. Therefore, the objective of this study is to explore the factors that enable SCSC's role in achieving SDGs, supported by technological capabilities. Thus, the current study focuses on filling the research gap by answering the following research questions based on this motivation.

RQ1. What are the enablers to achieve SDGs within supply chains from the perspective of CE and digital technologies for post-pandemic preparedness?

RQ2. What are the interrelationships among these enablers and how shall they be revealed?

In this context, CE and smart enablers, including digital technologies, were examined separately from the current literature and gathered under the title of SCSC enablers to achieve SDGs. After identifying the SCSC enablers, total interpretive structural modelling (TISM) was used to identify, reveal and interpret the relationships between these enablers since TISM is a powerful approach that can be conducted for the improvement of the consensus views in different settings and to recognize enablers, etc. into successful collaboration (Broome, 2002). In addition, the enablers of SCSC should be clarified, which can be beneficial for the elimination of this environment of uncertainty brought about by COVID-19. In this context, the TISM method, unlike other multi-criteria decision-making techniques, allows experts to evaluate the enablers and their interconnections, to shift ambiguous, weakly defined models of processes into explicit, possibly the best versions. Furthermore, the Matrice d'Impacts Croises Multipication Applique' a un Classement (MICMAC) technique, which is used in conjunction with TISM, contributes to this explanation by identifying the enablers and validating the TISM results in the study by classifying the enablers based on driving and dependency powers. The main contribution of this article is to identify the impact and role of enablers in achieving SDGs by combining smart and circular capabilities in the supply chain for the post-pandemic.

The organization of the paper is as follows; the theoretical background of the study is summarized in Section 2. The determined enablers for SCSC in achieving SDGs via NRBV are explained in Section 3. Section 4 mentions the methodology employed. The numerical study is shown in Section 5. Section 6 discusses the findings and gives the theoretical and managerial contributions of this study. Lastly, Section 7 explains the conclusion of the study.

2. Theoretical background

This section of the study looks into the methodologies and ideas utilized in the current literature on SCSC enablers to obtain a better understanding. In this context, it has been noted that enablers are discussed separately in the literature under the titles of CE or smart technologies, and the relevant enablers have been formulated during this study to be grouped under the same roof in the later stages of the study.

The majority of the publications which are taken into account related to the enablers of SCSC are supported by theoretical-based frameworks. For instance, Nandi *et al.* (2020) have conducted a qualitative study by focussing on the RBV, and resource dependence theoretical (RDT) approaches to reveal how firms respond to current disruptions such as the COVID-19 in the supply chain in terms of localization, agility and digitalization capabilities. Desing *et al.* (2020) proposed the sustainable RBV, which emphasizes specific obstacles for the transition to CE while focussing on the three pillars of sustainability. Jabbour *et al.* (2019) investigated the existing literature about green human resource management to improve and strengthen a conceptual and theoretical base on CE practices and dimensions. Stakeholder theory and RBV were employed to support the theoretical framework in this case to achieve SDGs. Jakhar *et al.* (2019) adopted an RBV and the stakeholder perspective to present a theoretical/ conceptual framework for effective implementation of CE practices and to achieve SDGs. Furthermore, the structural equation modelling (SEM) approach is applied to analyse the drivers for the CE initiatives such as innovation capabilities.

Some of the studies explicitly focused on enablers of digitalization towards CE. Kristoffersen *et al.* (2020) studied a theory and practice-based review that asserts digital technologies such as the Internet of things, big data, etc., are enormous enablers towards CE and contribute SDGs. Chen *et al.* (2020) conducted a systematic literature review to connect the research findings with the enablers in specific categories and sections depending upon the past 20 years' publication especially SC collaboration. The primary purpose of this paper is to display how these enablers can be used and adapted for the processes of the supply chain. Hussain and Malik (2020) investigated the effects of enablers on the CSC in terms of the environmental performance of supply chains by revealing the interaction among the organizational narrative (e.g. collaboration within the supply chain network, supply chain configuration and supply chain environmental performance etc.) and process facilitators via SEM. Lahane *et al.* (2020) presented a state-of-art review of the current literature of CSC management to emphasize the research trends, gaps, barriers and enablers of the CSC. Luthra *et al.* (2020) also focused on the key enablers and drivers of sustainability in supply chain issues. For the causal relationship among the drivers and enablers and to build an interrelationship diagram, empirical analysis and the grey-based decision-making trial and evaluation laboratory (DEMATEL) technique were employed. Pohlmann *et al.* (2020) carried a single case study to examine the role of the focal firm in attaining SDGs in a Brazilian food poultry supply chain. Keogh *et al.* (2020) concentrated on the future food chain in the aspect of positioning digitization as an enabler of society 5.0. By defining and emphasizing the connections between SSCM processes and UN SDGs, Zimon *et al.* (2020) performed research to evaluate the circumstances and challenges linked to the adoption of SDGs in supply chains. Martín-Gómez *et al.* (2019) examined the integration of digital technologies (I4.0 technologies), CE and organizational enablers as a holistic paradigm to provide adaptive and integrated SSC management. Some of the studies explicitly focused on enablers of smartness characteristic of the SC (e.g. digitalization) towards CE. In this context, Antikainen *et al.* (2018) underlined the primary digitalization opportunities and challenges as enablers during CE transition by conducting an empirical study (workshop). Rizos *et al.* (2016) determined the barriers and enablers that prevent SMEs to succeed in the CE business model by conducting a case study. Also, this study provides three pillars of sustainability framework and information of the green business model in the template of the case study. Faisal (2010) aimed to provide a successful approach by examining enablers that adopt sustainable practises for the transition of the supply chain via the ISM method.

3. SCSC in achieving SDGs via natural resource-based view

RBV theory is derived from strategic management and the theory of competitive advantage (Carter and Rogers, 2008) by using key resources and capabilities of the businesses. It mainly focuses on the positive effects of human resources management (HRM) and supports this idea theoretically (Jabbour *et al.*, 2019; Wright *et al.*, 1994). In RBV, organizational resources and capabilities have a significant effect on a firm's competitive strategies and performance (Chan, 2005; Barney, 1991; Grant, 1991; Rumelt, 1991; Dierickx and Cool, 1989). A firm's ability to deal with strict restraints caused by the natural environment (Chan, 2005; Hart, 1995) emphasizes the significance of irreplaceable, valuable and unique resources which are a precondition for a firm's competitive advantage (De Stefano *et al.*, 2016; Hart, 1995). For this purpose, this framework is considered as an extension of the RBV (De Stefano *et al.*, 2016; Barney, 1991; Wernerfelt, 1984) by explaining how firms achieve sustained competitive advantage (SCA) in ways that maintain the sustainability of natural resources and ecosystems (Michalisin *et al.*, 2010). NRBV provides a framework to firms to evaluate the various kinds of technological developments and innovations that can be used to address environmental constraints (De Stefano *et al.*, 2016). Thus, NRBV can be very useful for this study to understand the SC collaborations (Mishra *et al.*, 2019; Choi and Hwang, 2015) because it investigates various types of innovations and technologies that businesses may use to deal with environmental concerns (Mishra *et al.*, 2019; Alt *et al.*, 2015). In this view, competitive advantage has been examined depending upon three intertwined strategic capabilities as follows: pollution prevention, product stewardship and sustainable development (Grimstad and Burgess, 2014; Hart, 1995). Hence, this NRBV can assist SCSC through achieving SDGs because this view presents strategic capabilities for firms to product management, pollution prevention and sustainable development. Below, the NRBV has been proposed as a conceptual framework (see Table 1). In this context, the firm's key resources, strategic capabilities and enablers examined during the literature, which enablers are considered as an environmental driving force, have been examined in detail to achieve SDG.

3.1 SCSC enablers for achieving SDGs

Enablers are great facilitators for a smooth transition into an SCSC concept. Using the NRBV approach, the below-mentioned enablers (see Table 2) to achieve SDGs have been chosen considering the resources and capabilities for SCA. On databases, there is a range of research on sustainability and circularity enablers in supply chains to accomplish SDGs. Related articles were categorized in terms of their relevance to this study based on the circularity and smartness aspects of the publications (SDG connection). As a result of an extensive review of these existing research backgrounds, the most frequently mentioned and substantial enablers were discussed by a group of academicians (4) and determined as the most influential enablers that emphasize particular areas towards SDG achievement. In this context, sustainability potential of CE and I4.0, resource flexibility, resource availability and efficiency, cleaner technology, SC connectivity, green infrastructure, government support, innovation capacity, SC collaboration, and top management involvement were determined as the most frequently mentioned enablers in the literature which have an influence on the SCSC in terms of achieving SDGs for post-pandemic preparedness.

Strategic capability	Environmental driving force	Key resource	Competitive advantage
Pollution Prevention	Minimize resource use Minimize emissions, effluents and waste	Continuous improvement Environmental management	Lower costs Increased profitability
Product Stewardship	Minimize life-cycle cost of products Re-use of waste and water, renewable energy sources, packaging, reduced transport	Stakeholder integration Resources in value chain assessed Environmental certification and standards	Pre-empt competitors. through exclusive access and/or environmental barriers
Sustainable Development	Minimize environmental burden of firm growth and development	Shared vision Environmental Strategy	Securing future position

Source(s): Grimstad and Burgess, 2014; Hart, 1995

Table 1. Natural resource-based view

Enablers		Definition	References
E1	Sustainability potential of CE and I4.0	Comprehension and awareness of the opportunity and potential that CE and I4.0 can offer in the context of sustainability can be counted as a substantial enabler for achieving the SDGs	Hussain and Malik (2020), Lahane *et al.* (2020), Agyemang *et al.* (2019), Bressanelli *et al.* (2019), Tura *et al.* (2019), Moktadir *et al.* (2018)
E2	Resource flexibility	The ability to modify resources (workers, equipment, tools, variety of products) and adapt to various situations such as output level, schedule, design, function, purpose, used materials in a flexible way	Hussain and Malik (2020), Lahane *et al.* (2020), Bressanelli *et al.* (2019), Singhal *et al.* (2019), Tura *et al.* (2019)
E3	Resource availability and efficiency	Availability of the resources at any given time and properly and efficient usage and management of these resources in accordance with their objectives and in a sustainable manner	Lahane *et al.* (2020), Agyemang *et al.* (2019), Tura *et al.* (2019), Moktadir *et al.* (2018)
E4	Cleaner technology for renewable energy	The usage of more sustainable resources such as renewable energy and cleaner technology can reduce the negative impacts on environmental problems	Lahane *et al.* (2020), Govindan and Hasanagic (2018), Moktadir *et al.* (2018)
E5	SC Connectivity	SC connectivity, which also named as smart technologies-oriented supply chain, provide smart, innovative, and integrated solutions by using the right technologies in the most appropriate way in SCs for sustainable development and excel CE's principles	Lahane *et al.* (2020), Luthra *et al.* (2020), Alcayaga *et al.* (2019), Martín-Gómez *et al.* (2019), Tura *et al.* (2019)
E6	Green infrastructure	Green infrastructure is building a durable, cost-effective and circular network that can be used through effective management of sustainability by protecting natural resources	Hussain and Malik (2020), Lahane *et al.* (2020), Luthra *et al.* (2020), Alcayaga *et al.* (2019), Martín-Gómez *et al.* (2019), Singhal *et al.* (2019), Tura *et al.* (2019), Govindan and Hasanagic (2018), Moktadir *et al.* (2018)
E7	Governmental support	Government support, effective legislation and provision of funding and incentives to allow more initiatives on sustainable issues and their improvement	Lahane *et al.* (2020), Luthra *et al.* (2020), Moktadir *et al.* (2018), Rizos *et al.* (2016)
E8	Innovation capacity	Providing innovative strategies and R&D activities can facilitate the transition to SCSC and SDGs accomplishment	Lahane *et al.* (2020), Agyemang *et al.* (2019), Tura *et al.* (2019)
E9	SC collaboration	The cooperation and collaboration among supply chain partners in terms of information sharing, expertise etc. can deliver crucial benefits and advantages in terms of sustainability manner	Chen *et al.* (2020), Hussain and Malik (2020), Lahane *et al.* (2020), Luthra *et al.* (2020), De Angelis *et al.* (2018), Govindan and Hasanagic (2018), Moktadir *et al.* (2018), Rizos *et al.* (2016)
E10	Top management involvement	The role, commitment and involvement of top management promote the promotion of sustainability initiatives in terms of providing resource support and incentives	Lahane *et al.* (2020), Nandi *et al.* (2020), Graves *et al.* (2019), Bag *et al.* (2018), (2018), Dubey *et al.* (2018), Faisal (2010)

Table 2.
Enablers of SCSC to achieve SDGs

3.1.1 Sustainability potential of CE and I4.0. CE ensures the efficient use of resources by incorporating the principles (10R) and integrating them into the entire operations of the SCs and closes the loop for continuous improvement and effective management of the environment by eliminating pollution, waste, emissions and effluents. Hence, awareness of CE-driven sustainability provides benefits such as cost savings (Tura *et al.*, 2019), revenue gains (Bressanelli *et al.*, 2019) transition into a CSC (Tura *et al.*, 2019; Moktadir *et al.*, 2018).

3.1.2 Resource flexibility. CE can assist agility by modifying resources and providing different solutions to various conditions efficiently and promote shared economy practices, which makes for greater resource flexibility (Nandi *et al.*, 2020). Resource flexibility promotes the achievement of SDGs as an environmental strategy by reducing the lifecycle cost of products and enabling the reuse of waste and water. For this reason, the success of manufacturing flexibility is highly related to the firm's ability to have resource flexibility, which distributes the financial, human and physical resources allow local decisions on the partnerships' goals and policies to be implemented (Chauhan and Singh, 2014).

3.1.3 Resource availability and efficiency. In terms of materials and production, many factories were shut down owing to lockdowns, and output is hampered due to a lack of raw materials (Modgil *et al.*, 2021; Belhadi *et al.*, 2021; Handfield *et al.*, 2020). The resource availability shows the intensity of resource needed to be minimized to become more environmentally friendly and sustainable (Desing *et al.*, 2020). Resource availability and efficient usage of these resources with smart technologies can facilitate the implementation of the CE principles and assist firms to use their resources and capabilities in an effective way towards achieving SDG and competitive advantage.

3.1.4 Cleaner technology for renewable energy. Clean technologies using renewable energy (solar, wind, water, etc.) including green transportation, green chemistry, information technology and energy-efficient appliances have become a growing interest for financing despite of significant difficulties in the capital market (Erzurumlu and Erzurumlu, 2013; Noci and Verganti, 1999). Therefore, with the adoption of clean and green technologies, the transition into circular business models is an enabler rather than a barrier (Rizos *et al.*, 2016). The reason underneath of considering these clean technologies as a facilitator of a sustainable economic system is because it assists the economy in reducing carbon footprint during a sustainable transition to CE (Acemoglu *et al.*, 2016).

3.1.5 SC connectivity. Smart technologies are a combination of connected, collaborative and cognitive technologies, machines, databases, storage space, sensors, etc. that are capable to analyse the data and adapt or modify behaviour depending on the environment surrounded them. The improvement of smart technologies assists SC connectivity to become more effective, efficient, reactive (Luthra *et al.*, 2020) and smart. Hence, improved smart technologies can provide operational efficiency, advanced data control and eliminated wastes of energy for both machines and processes. Thus, it becomes one of the most substantial enablers towards CE by increasing productivity and allowing just-in-time concepts to be implemented to support continuous production (Nascimento *et al.*, 2019).

3.1.6 Green infrastructure. Green infrastructure is a network of conservation areas, nature reserves, green spaces and greenway links that provides many environmental benefits (Council, 2011) to build robustness and cost-effective connection that aims to excel in business sustainability. Green infrastructure is also considered an integrated concept and pathway towards sustainable development due to its features of generation quality of life (Council, 2011). Also, green infrastructure can be associated with SDG 9 which is Industry, Innovation and Infrastructure.

3.1.7 Government support. Strong government support by effective policies, legislation, funding and execution plays a key role for businesses to adopt CE practices into their processes. As governmental support aims to support sustainable development through an intense partnership among public institutions, businesses, practitioners and academia (Houston *et al.*, 2019), Houston *et al.* (2019) also added that governments offer many opportunities, such as encouraging actions those facilitate the adoption of CE and accelerate this transition and provide innovation to support circular business models and make it a priority in the national strategies.

3.1.8 Innovation capacity. The organizational capabilities, that enable to maintain innovation, have a key role to encourage firms to adopt these sustainability initiatives such as CE (Jakhar *et al.*, 2019; Berrone *et al.*, 2013; Buysse and Verbeke, 2003; Brunnermeier and Cohen, 2003; King and Lenox, 2002; Jaffe and Palmer, 1997; Porter and Van der Linde, 1995) and smart technologies. Sustainability pushes businesses to manage their processes differently and leading them into innovation and sustainable development (Faisal, 2010). Thus, three intertwined concepts (CE, sustainability and innovation) can support each other for the transition into SCSC and excel in SDGs.

3.1.9 SC collaboration. SC collaboration refers to two or more separate companies working together to organize and conduct supply chain activities (Dubey *et al.*, 2019), and it involves cooperation, information sharing, mutual understanding, decision synchronization, collective effort and incentive alignment (Hussain and Malik, 2020; Rota *et al.*, 2018). Strong relationships with suppliers lead to superior performance (Dubey *et al.*, 2019; Wilding *et al.*, 2012; Reuter *et al.*, 2010; Jabbour and Jabbour, 2009). This strong collaboration and collaboration among SC partners influence many vital decisions, from supplier engagement (Petljak *et al.*, 2018), training and development of supplier (Walker and Jones, 2012), supplier choice (Malik *et al.*, 2016) to environmental collaboration with customers (Hussain and Malik, 2020; Schaltegger *et al.*, 2014).

3.1.10 Top management involvement. CE practices require structural orientation within organizations (Houston *et al.*, 2019) which is reflected by the choices, values and biases of top management (Dubey *et al.*, 2019; Hambrick and Mason, 1984). Therefore, the role of top management is critical resulting from the decisions connected with the organization and policies for the change (Dubey *et al.*, 2019). Top management involvement may promote the transition to circularity by considering it as an economic advantage and implementing top-down strategies on behalf of long-term planning and investment (Houston *et al.*, 2019). In general, eco-friendly organizations are likely to depend on the top management involvement, which results in an advanced competitive advantage (Latan *et al.*, 2018; Spencer *et al.*, 2013; Porter and Van der Linde, 1995).

4. Methodology

As a methodology, TISM has been chosen to examine the enablers obtained from the current literature for the Turkey's food industry. Next, MICMAC analysis is employed to classify the enablers based on their dependence and driving powers. This section of this study explains the methodology adopted from Mathivathanan *et al.* (2021) and Shibin *et al.* (2017) which is shown in Figure 1.

4.1 TISM methodology

TISM attempts to answer three basic questions of theory development: "what" by showing the nods as variables, and "why" and "how" by showing interlinks (Sushil, 2012). In this sense, TISM is an important technique that can be used to strengthen consensus views in various situations and to identify enablers of effective cooperation of SCSC and NRBV. In this study, TISM is applied to capture the dynamic complexities of post-pandemic preparedness to achieve SDGs through SCSC and achieve a summarized realistic picture of the situation. The process involves nine steps which are explained below:

Step 1. *Identify and define enablers:* The first step of TISM is to describe and establish the enablers on which interactions will be developed. Identification of these enablers may be accomplished by the use of current literature or some concept creation

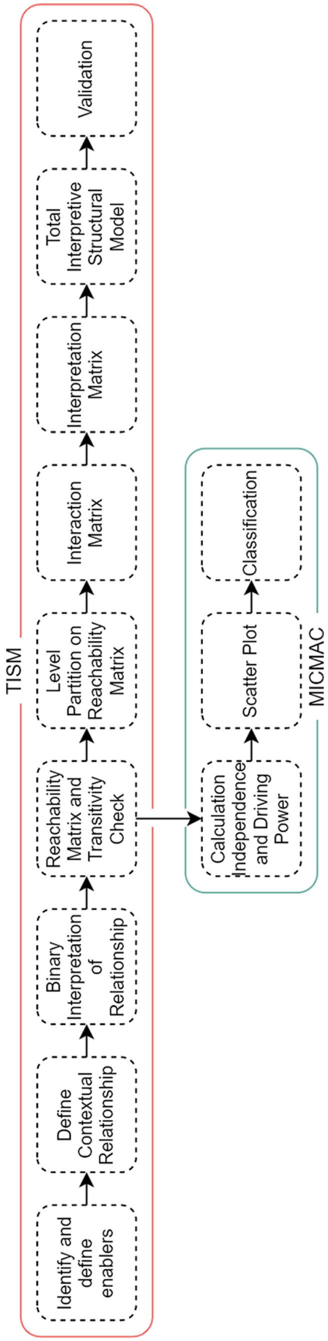


Figure 1.
TISM and MICMAC methodology

technique (Jena *et al.*, 2017). In this study, various enablers of SCSC are decided for leading SDGs for post-pandemic preparedness through a comprehensive literature review and expert's inputs.

Step 2. *Define contextual relationships*: It is critical to specify the contextual relationship among the enablers which this contextual relationship is usually determined by the type of system being studied, such as preference, purpose manner, quality improvement, etc. (Jena *et al.*, 2017). Therefore, contextual relationships between the enablers are defined via expert opinions such as enabler E1 will help to achieve enabler E2, including an interpretation for each enabler. The descriptions of the impact between enablers are recorded in a knowledge base matrix with the assistance of discussions with the experts using YES/NO answers and logical reasoning. The profile of the experts is seen in Appendix Table A1.

Step 3. *Binary interpretation of relationships:* This is essentially the initial step in the TISM which is expected to explain the conventional ISM further. In TISM, the interpretation of a connection is clarified by considering how one element can affect or enhance another element. Each element is independently compared to each other in a pair-wise comparison (Jena *et al.*, 2017).

Step 4. *Reachability matrix and transitivity check*: At this step, initial reachability matrix is checked for the transitivity rule. The transitivity rule occurs when Ex affects Ey and Ey affects Ez, therefore, Ex affects Ez (Dubey *et al.*, 2015; Jayalakshmi and Pramod, 2015; Mathivathanan *et al.*, 2021). The logic knowledge base is revised after a new transitivity (Sushil, 2012) exists. Since there are two potential directional relations *i-j* and *j-i*, the total number of pair-wise comparisons for *n* defined elements is *n* * (n1). Finally, "*n* * (n1)" lines are created in the knowledge base for conducting analysis. For each pair-wise comparison, experts' opinions are expressed by input codes "*Y*" for yes and "*N*" for no, and if "*Y*", it is also explained (Jena *et al.*, 2017).

Step 5. *Level partition on reachability matrix:* After the final reachability matrix, the next step is level partitioning, which progresses by grouping the enablers into ranking levels (Shibin *et al.*, 2017). The enablers at the highest level do not connect the enablers over their level (Mathivathanan *et al.*, 2021; Mathiyazhagan *et al.*, 2013). Levels are determined by starting from level I. Once the interaction set is same with reachability set, the enabler is identified as level I. Next, the set is revised by eliminating the enabler that assigned with a level from the set. This process continues until all enablers are assigned to a level.

Step 6. *Interaction matrix*: The logical reasons are entered instead of binary value of 1 in order to construct the interaction matrix. In this matrix, only those links that are defined as effective links and have a significant relationship (Dubey *et al.*, 2015; Jayalakshmi and Pramod, 2015; Mathivathanan *et al.*, 2021).

Step 7. *Interpretation matrix*: In this step, logical reasoning of each positive relationship is entered on each corresponding cell on the interaction matrix and interpretation matrix is obtained as a result. In this study, a 10 × 10 interpretive matrix is developed by providing entries from the logic knowledge.

Step 8. *TISM model*: The diagraph is created based on the levels obtained in the previous step. Each enabler is placed on the top to the bottom of the diagraph starting from the level I to level IV, respectively. The links between the enablers are interpreted with arrows depending on the final reachability matrix. Direct links are represented by solid arcs meanwhile transitivity links are represented by dashed arcs. The diagraph is retrieved by adding the logical reasons on the corresponding arcs.

Step 9. *Validation*: At the beginning of this evaluation, experts evaluated 90 pair-wise comparisons consisting of 10*9 enablers. As a result of this evaluation, a total of 23 meaningful relationships were obtained. In terms of enablers and relationships between the enablers, the model structure must be validated (Sushil, 2012). This process is carried out by providing answers for the following questions suggested by Sushil (2012) by considering all enablers and the relationships via group consensus with the experts,

(1) Are all relevant enablers are included?

(2) Is the interpretation of relations, correct?

(3) Are the interpreting paths correct?

4.2 MICMAC analysis

The MICMAC is acknowledged as Matrice d'Impacts Croises Multipication Applique' a un Classement (cross-impact matrix multiplication applied to classification) (Mathivathanan *et al.*, 2021). The MICMAC examines the influence of enablers as assessed by relationships (Diabat *et al.*, 2013, 2014; Dubey and Ali, 2014; Jain and Raj, 2015; Mathivathanan *et al.*, 2021).

5. Case study

The enablers identified throughout the current literature are as follows: sustainability potential of CE and I4.0 (E1), resource flexibility (E2), resource availability and efficiency (E3), cleaner technology for renewable energy (E4), SC connectivity (E5), green infrastructure (E6), governmental support (E7), innovation capacity (E8), SC collaboration (E9) and top management involvement (E10). For second step of the TISM method, ten industry experts from meat industry seen in Appendix Table A1 were chosen and these experts evaluated 90 paired relationships of the enablers for their contextual relationship. The sector is selected as meat since meat and other animal-derived foods have been linked to significant resource waste (Garske *et al.*, 2020). Each expert has at least three years of significant industrial experience. All of the identified experts responded to the evaluation questions. In addition to that, the contextual relationships between the enablers are also defined via expert opinions while conducting the surveys. In this context, the question was asked to each expert for each paired enablers: *is there any relationship between paired enablers to achieve SDGs? YES/NO, if YES, explain why and which SDGs can be achieved?* Accordingly, the interpretive knowledge base was developed based on their logical reasoning as seen in Table 3.

#	Enabler	Paired comparison	Is there a relationship?	The logical reasoning
1	E1-E2	Sustainability potential of CE and I4.0 will help to achieve resource flexibility	YES	Sustainability potential enhances the ability of the resources to manage a wide range of manufacturing operations effectively
.	.	.	.	.
.	.	.	.	.
90	E9-E10	SC collaboration will help to achieve top management involvement	NO	.

Table 3. The interpretive logic knowledge base

In order to establish the interpretive logic knowledge base, the experts were required to deliver a pair-wise contextual relationship between all enablers. In this study, ten enablers were considered in total, therefore, a total of 90 (10*9) potential relationships were discussed with the experts. The existence of a positive relationship (YES) between enablers required a majority of expert opinions with more than 50%; otherwise, it was recorded as a negative relationship (NO) for the comparative measure (Mathivathanan *et al.*, 2021). Furthermore, a pair-wise comparison matrix was created in terms of 10 × 10 matrixes, which is achieved by transforming the interpretive logic knowledge base seen in Table 3 (Sushil, 2012). The initial reachability matrix is achieved by this transformation. The value of “1” or “0” is given depending on the relationship between enabler Ei and the enabler Ej for each (*i,j*)th cell (Sushil, 2012). In this matrix, only the direct relationships are shown in Table 4.

After establishing initial reachability matrix (step 3), the transitive links obtained after applying the transitivity rule are highlighted in purple meanwhile direct links are highlighted in green which is step 4. Each transitive link is evaluated via expert opinions. Following the revision, only the most effective links are accepted for the study. At the end of this stage, final reachability matrix is obtained as seen in Table 5.

In step 5, level partitioning is progressed by grouping the enablers into ranking levels depending on the effects of each enabler on other enablers (Shibin *et al.*, 2017). Then, reachability set, the antecedent set and the intersection set are all defined by deriving from final reachability matrix as demonstrated in Table 6, which is step 6.

In next stage, a 10 × 10 matrix is created similar to final reachability matrix. In this matrix, only the joints that are characterized as effective and have a meaningful connection are shown in Table 7.

As the final matrix, a 10 × 10 interpretive matrix is developed by providing entries from the logic knowledge base as seen in Table 8.

After the determination of the final matrix, the final step of the TISM, validation of the TISM model, is required for the reliability assessment of the study. In this context, an additional questionnaire containing the relationships of the final matrix and logical reasoning

Table 4.
Initial reachability matrix

Enabler		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Sustainability potential of CE and I4.0	E1	1	1	1	1	0	1	0	0	0	0
Resource flexibility	E2	1	1	0	0	0	1	0	0	0	0
Resource availability and efficiency	E3	0	0	1	0	0	0	0	0	1	0
Cleaner technology for renewable energy	E4	1	0	0	1	0	0	0	0	0	0
SC connectivity	E5	0	0	1	0	1	0	0	1	0	0
Green infrastructure	E6	0	0	0	0	0	1	0	0	0	0
Governmental support	E7	1	0	0	0	1	1	1	1	1	0
Innovation capacity	E8	0	0	0	0	1	0	0	1	0	0
SC collaboration	E9	1	0	0	0	1	0	0	0	1	0
Top management involvement	E10	1	0	0	0	0	0	0	1	1	1

Table 5.
Final reachability matrix

Enabler		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Sustainability potential of CE and I4.0	E1	1	1	1	1	0	1	0	0	1	0
Resource flexibility	E2	1	1	1	1	0	1	0	0	0	0
Resource availability and efficiency	E3	1	0	1	0	1	0	0	0	1	0
Cleaner technology for renewable energy	E4	1	1	1	1	0	1	0	0	0	0
SC connectivity	E5	0	0	1	0	1	0	0	1	1	0
Green infrastructure	E6	0	0	0	0	0	1	0	0	0	0
Governmental support	E7	1	1	1	1	1	1	1	1	1	0
Innovation capacity	E8	0	0	1	0	1	0	0	1	0	0
SC collaboration	E9	1	1	1	1	1	1	0	1	1	0
Top management involvement	E10	1	1	1	1	1	1	0	1	1	1

of each positive relationship was prepared for the validation assessment and sent to additional 12 experts who are apart from previous sample, a heterogeneous group consisting of academics and industry experts. In this context, the same question was asked to each expert for all paired enablers. Depending on the results obtained from the experts, the average score of each link were calculated and decided to accept or reject these positive links depending upon the threshold value which is below 3,00 (see Appendix Table A2).

According to the calculations of the responses obtained from the experts, only one link among 34 interactions or links is determined as not important which was cleaner technology for renewable energy and resource availability and efficiency link (2.92). This value is lower than the threshold value (3.00) thus, it is recommended to reject the link and accept them otherwise. However, since only one link was considered as not important and the threshold value was close to the accepted value, it was decided to join this link model. Furthermore, other interactions apart from this link were generally consistent, and also the average score of the model was consistent. Therefore, the model was accepted because the threshold value was above the 3.00. Therefore, the TISM model did not change after validation, and below presented Figure 2 is the validated version of the TISM model.

Direct links are represented by solid arcs meanwhile transitivity links are represented by dashed arcs. The final TISM model is shown in Figure 2. The diagraph is retrieved by adding the logical reasons on the corresponding arcs.

Also, a TISM model is created for each related SDGs. Each interaction of enablers enhances at least one SDG. The developed TISM model for achieving SDGs is shown in Figure 3.

For MICMAC, dependence and driving powers are calculated for each enabler based on the final reachability matrix as seen in Table 9. While dependence values represent the x axis, the driving powers represent the y axis.

The diagram seen in Figure 4 was retrieved as the result of MICMAC analysis.

Enabler	Reachability set	Antecedent set	Intersection set	Level
E1	1,2,3,4,6,9	1,2,3,4,7,9,10	1,2,3,4,9	II
E2	1,2,3,4,6	1,2,4,7,9,10	1,2,4	II
E3	1,3,5,9	1,2,3,4,5,7,8,9,10	1,3,5,9	I
E4	1,2,3,4,6	1,2,4,7,9,10	1,2,4	II
E5	3,5,8,9	3,5,7,8,9,10	3,5,8,9	I
E6	6	1,2,4,6,7,9,10	6	I
E7	1,2,3,4,5,6,7,8,9	7	7	IV
E8	3,5,8	5,7,8,9,10	5,8	II
E9	1,2,3,4,5,6,8,9	1,3,5,7,9,10	1,3,5,9	III
E10	1,2,3,4,5,6,8,9,10	10	10	IV

Table 6. Level partition of enablers

Enabler		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Sustainability potential of CE and I4.0	E1		1	1	1	0	1	0	0	1	0
Resource flexibility	E2	1		1	0	0	1	0	0	0	0
Resource availability and efficiency	E3	1	0		0	1	0	0	0	1	0
Cleaner technology for renewable energy	E4	1	0	1		0	1	0	0	0	0
SC connectivity	E5	0	0	1	0		0	0	1	1	0
Green infrastructure	E6	0	0	0	0	0		0	0	0	0
Governmental support	E7	1	0	0	1	1	1		1	1	0
Innovation capacity	E8	0	0	1	0	1	0	0		0	0
SC collaboration	E9	1	0	1	0	0	0	0	1		0
Top management involvement	E10	1	1	1	1	0	0	0	1	1	

Table 7. Interaction matrix

Table 8.
Interpretive matrix

Enabler	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
E1		Sustainability potential enhances the ability of the resources to manage a wide range of manufacturing operations	Sustainable practices enable access to resource and efficient utilization	Enhancing solar, wind powered technology for the production of renewable energy	0	Protection and improvement of water, waste reduction in ecosystem	0	0	Sustainability potential underpins the beneficial role of collaboration	0
E2	Resource flexibility intensifies sustainability potential		Resource flexibility empowers resource availability and efficiency	0	0	Resource flexibility enables enhanced green infrastructure	0	0	0	0
E3	Resource availability and efficiency enables sustainability potential	0		0	Resource availability and efficiency requires the information and physical flows in SC	0	0	0	Resource availability and efficiency boosts collaboration	0
E4	Cleaner technology for renewable energy enhances sustainability potential	0	Renewable energy boosts availability and efficiency of resource		0	Cleaner technology for renewable energy enhances green infrastructure	0	0	0	0
E5	0	0	Affordable and equitable resources through access to information and communications technology	0		0	0	The access to information and communications technology expands innovation capacity	SC connectivity strengthens global collaboration via resource efficiency	0
E6	0	0	0	0	0		0	0	0	0

(*continued*)

Table 8.

Enabler	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
E7	Providing government support that allows sustainability potential to apply real-life practices	0	0	Expanding renewable energy, energy efficiency in accordance with governmental support	Connecting to SC members can be facilitated with governmental support	Governmental support enhances quality, reliable, sustainable and green infrastructure		Governmental support enables domestic technology development, research, and innovation	Strengthening sound policies and enforceable legislation	0
E8	0	0	Provides new opportunities for efficient use and availability of resource	0	Innovation encourages the use of enabling technology, especially information and communications technology	0	0		0	0
E9	Sustainability potential can be facilitated by collaboration	0	Promoting access and efficiency to resource via sharing between SC members	0	0	0	0	Collaboration delivers new insights in terms of innovation capacity		0
E10	Providing new partnerships for sustainability	Planning resource usage in a broad range of production	Enhancing sustainable management of resources	Investing in cleaner technologies and energy	0	0	0	Facilitating research and development	Broaden and strengthen the involvement of the top management ensures responsive, inclusive, participatory and representative decision-making	

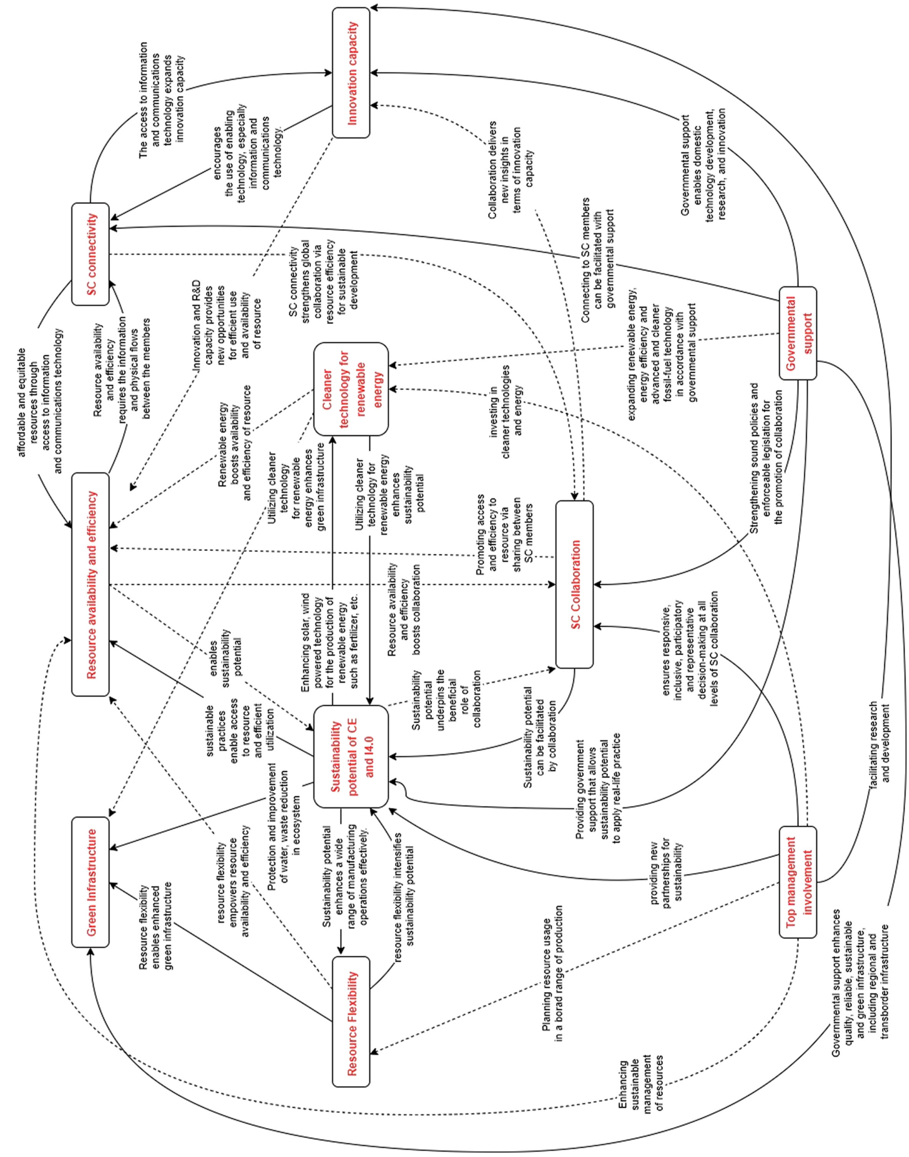
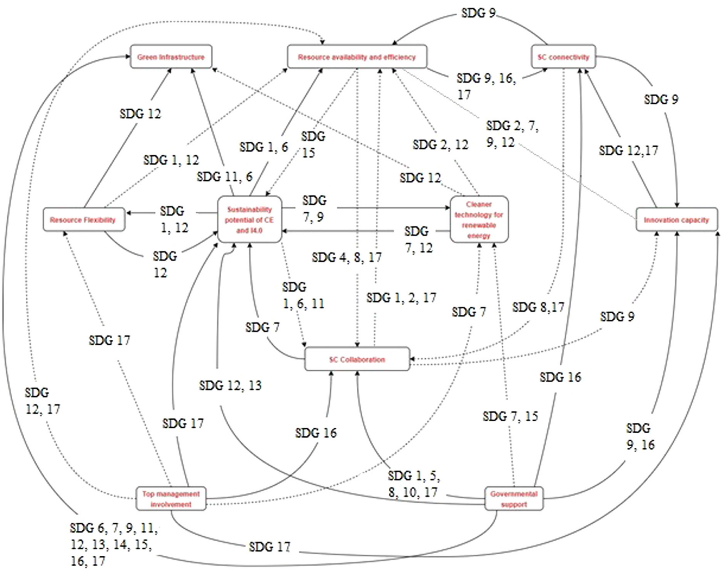


Figure 2.
TISM model with validation



SDG 1 No Poverty = 6 links
SDG 2 Zero Hunger = 3 links
SDG 3 Good Health and Well-being = 0 link
SDG 4 Quality Education = 1 link
SDG 5 Gender Equality = 1 link
SDG 6 Clean Water and Sanitation = 4 links
SDG 7 Affordable and Clean Energy = 7 links
SDG 8 Decent Work and Economic Growth = 3 links
SDG 9 Industry , Innovation and Infrastructure = 8 links
SDG 10 Reduced Inequalities = 1 link
SDG 11 Sustainable Cities and Communities = 3 links
SDG 12 Responsible Consumption and Production = 12 links
SDG 13 Climate Action = 2 links
SDG14 Life below Water = 1 link
SDG 15 Life on Land =3 links
SDG 16 Peace, Justice and Strong Institutions = 5 links
SDG 17 Partnerships for the Goals = 11 links

Figure 3.
TISM model for achieving SDGs

Enablers	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Dependence	7	6	9	6	6	7	1	5	6	1
Driving Power	6	5	4	5	4	1	9	3	8	9

Table 9.
Dependence and driving powers of enablers

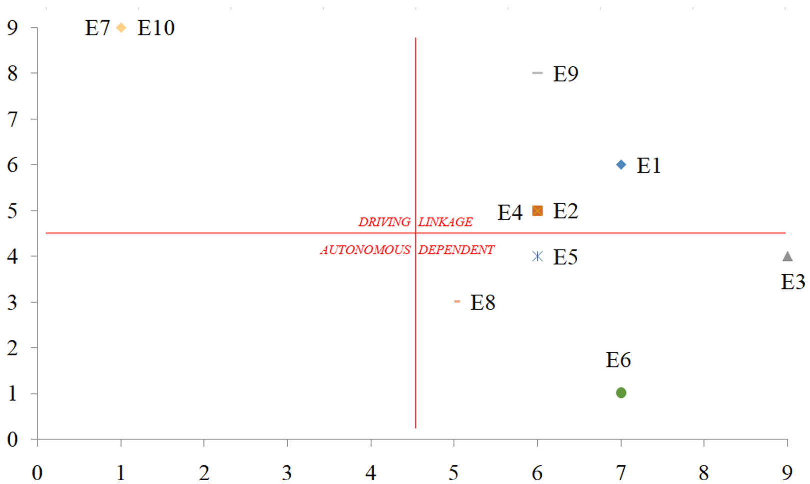


Figure 4.
MICMAC diagram

The diagram represents the enablers in four quadrants which are driving, linkage, autonomous and dependent. None of the enablers are identified as autonomous which refers to low driving and dependence powers. Dependent enablers are defined as E3: Resource availability and efficiency; E5: SC Connectivity; E6: Green infrastructure and E8: Innovation capacity. Moreover, linkage enablers have high dependence and driving powers which are E1: Sustainability potential of CE and I4.0; E2: Resource flexibility; E4: Cleaner technology for renewable energy and E9: SC collaboration. Lastly, E7: Governmental support and E10: Top management involvement is the driving enablers with high driving power however not dependent.

6. Discussion of findings

This section of the study mainly outlines the exploration of the enablers of the SCSC in order to achieving SDGs for post-pandemic preparedness from theoretical perspectives. In this context, current literature was scrutinized to identify SC enablers from both smart technologies and CE perspective. Then, structured questionnaires conducted to the group of experts for applying TISM method and MICMAC analysis and make a connection among these enablers, their transitive interactions and interpret their causal interactions in the first phase. After implementation of the questionnaire, analyses made to propose a framework that can assist companies to adapt circular and smart initiatives to achieve SDGs.

In existing literature, the TISM approach has been commonly used by scholars in a variety of fields of study (Yadav, 2014; Srivastava and Sushil, 2013; Wasuja *et al.*, 2012; Nasim, 2011; Prasad and Suri, 2011). For instance, Dubey *et al.* (2015) adopted TISM method to provide a framework by determining enablers of green supply chain management (GSCM) as a guideline for future research studies. Furthermore, Shibin *et al.* (2016) proposed both enablers and barriers of green supply chain for flexible network and used TISM modelling for developing a contextual interaction depending upon expert's opinion. Furthermore, there are many studies in the existing literature that deals with enablers of SC and CSC. For instance, Hussain and Malik (2020) scrutinized the existing literature and determined the organizational enablers of CSC and tried to examine the relationship between CSC and its effects on environmental performance. Besides, Khan *et al.* (2020) also addressed to the key enablers of supply chain for implementation of the circular initiatives. However, the main contribution of this study is to add smart technology perspectives to the CSC as a promoter towards achieving SDGs.

The findings of this study show that E3: Resource availability and efficiency; E5: SC Connectivity and E6: Green infrastructure are positioned as the first level of the model (see Table 6). In addition to that, E1: Sustainability potential of CE and I4.0; E2: Resource flexibility and E8: Innovation capacity are considered as the second level of the model. MICMAC analysis represents that none of the mentioned enablers during the study can be categorized under autonomous variables (see Figure 3) which means all enablers are necessary for achieving SDGs. Also, E7: Governmental support and E10: Top management involvement are classified under the driving enablers. It can be deduced that these enablers have high influential effect caused by their high driving power and low dependence (Chandramowli *et al.*, 2011) for achieving SDGs. Furthermore, E1: Sustainability potential of CE and I4.0; E2: Resource flexibility; E4: Cleaner technology for renewable energy and E9: SC collaboration enablers are classified under linkage variables which mean they have high dependence and driving power. Thus, these enablers can be affected by their own action which makes them unpredictable and difficult to handle (Chandramowli *et al.*, 2011). Lastly, E3: Resource availability and efficiency; E5: SC Connectivity; E6: Green infrastructure and E8: Innovation capacity enablers are categorized under dependent variables which leads low driving power and high dependence on other variables. These enablers have low influential effect on other variables and easily can affect by other variables.

In this context, enablers that have high influential effect (driving force) and low dependence such as E7: Governmental support and E10: Top management involvement requires enormous attention to create a meaningful impact on the entire system. Therefore, the findings presented in this study can visualize the entire SC system and provide solutions enable guideline for these SC tiers in order to facilitate the decision-making process in terms of achieving SDGs. Collaborative and cooperative commitment and solidarity from government, policymakers, top managers can accelerate the transition into circular activities and smart technology adoption for the achievement of the SDGs. In addition to that when Figure 3. TISM model for achieving SDGs were examined, it has been found that SDG 12: Responsible Consumption and Production (12 links) and SDG 17 Partnerships for the Goals (11 links) are the most frequently relevant SDGs that is linked with the enablers.

6.1 Theoretical contributions

As a theoretical approach, NRBV has been adopted in this study to minimize the environmental damage and burden, use it as an environmental strategy and achieve competitive advantage. Because this approach provides strategic capabilities for businesses in product management, pollution reduction and sustainable development, the article contributes to the literature by proposing NRBV to assist SCSC in attaining SDGs. Company's primary resources, strategic capabilities and enablers explored throughout the literature, which enablers are deemed an environmental driving force, have been assessed to attain SDG.

6.2 Managerial and practical contributions

The identification and analyses of enablers assists experts of supply chain and strategy policymakers in identifying crucial areas that require immediate attention and care (Shibin *et al.*, 2016). In this context, the results of this study show that the enablers that have the most driving forces and not depend on any other enablers are governmental support and top management involvement. Governments have the power to have direct impact on businesses and entire sector by providing support via laws and regulations, funds, incentives, programs etc. Therefore, by focussing on only these two enablers can create a significant difference for the post-pandemic in terms of being resilient on entire sector. Furthermore, top management involvement plays a substantial role in the SDGs on a smaller scale compared to government. Therefore, for businesses side, this resultant model provided by this study can be applied to different sectors such as manufacturing, automotive etc. The results depicted in this study are representing the main facilitators that businesses can adopt in order to achieving SDGs and building resilience for the post-pandemic situations. Thus, this study can be provide guideline for the governments and policymakers pointing out the key enablers for achieving SDGs. Enablers such as E1: Sustainability potential of CE and I4.0; E2: Resource flexibility; E4: Cleaner technology for renewable energy and E9: SC collaboration are highly dependent and high driving power. In light of this information, required attention on these enablers is needed at the government, policymakers and top manager's level which can be easily affected by the government legislations and top management efforts.

7. Conclusion

Amidst COVID-19 pandemic, restrictions and lockdowns caused serious interruptions in the supply chains which lead problems to meet customer demands, and supply chain fragility and flexibility. Many companies were among those most affected by this ongoing pandemic, and it was seen that they were not prepared for such crisis periods. Therefore, the importance of transitioning to SCSC may be a preparation to offer a solution to mitigate the concerns and harms associated with COVID-19 for the post-pandemic. Identifying the SCSC's enablers, which aim to successfully apply the concepts of smart and circularity to the supply chain, is crucial in achieving the SDGs. In this respect, CE and smart enablers were separately examined in the current literature based on NRBV theory as a theoretical background and subsequently gathered under SCSC enablers. The reason behind using NRBV is because that this theory endeavours to understand the strategic capabilities and key resources along with using different innovations and technologies and to deal with environmental issues. Furthermore, it provides a competitive advantage to firms by managing the products effectively, preventing pollution and supporting sustainable development. Thus, this view is a great fit for achieving SDGs on a firm-level. Besides, corporate social responsibility, green economics and stakeholder theories can also be adopted for these kinds of studies as a theoretical background. After identification of the SCSC enablers, the TISM method adopted to analyse the interactions among enablers and interpret the findings. The present study is providing a theoretically supported guideline and a framework for businesses by using TISM that they can promote their objectives to the next level in terms of achieving SDGs for the post pandemic preparation.

The main limitation of this study is the sample size of the study, the survey which was sent to ten industry experts working in the food supply chain (meat sector). In this case, the sample of the study can be extended for future research. The case study is adapted to the meat sector since this study mainly focuses on the identification and analysis of the SCSC enablers. For this purpose, the results of this study are unique to the meat sector only. In addition, that this study can be integrated into various supply chain areas such as Fast-moving consumer good (FMCG), automotive, retail, etc. which are affected by COVID-19 on a broad scale. Also, a framework can be presented for a deeper understanding regarding this context and how these enablers can facilitate SDG achievement. Besides, further research might also focus on only one tier of the supply chain, such as production, distribution, etc.

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Corresponding author
Yasanur Kayikci can be contacted at: yasanur.kayikci@gmail.com; yasanur@tau.edu.tr

Appendix

Expert #	Occupation	Experience (Year)
1	Purchasing Manager	14
2	Warehouse Shipping Manager	5
3	Quality Assurance Manager	8
4	Fresh Food (Meat) Category Specialist	6
5	Production Director	11
6	Procurement Specialist	7
7	Processed Meat Category Executive	3
8	Human Resources Manager	14
9	Food Engineer	4
10	Production Executive	12

Table A1. Profile of the experts

#	Paired comparison of enablers	1	2	3	4	5	6	7	8	9	10	11	12	Average score for each link	Average score for the model
1	Sustainability potential of CE and I4.0/SC collaboration	5	4	4	5	3	5	4	5	5	4	4	4	4,33 Accept the link	4,00 Accept the model
2	Sustainability potential of CE and I4.0/Green Infrastructure	4	4	3	5	4	5	4	4	5	4	3	4	4,08 Accept the link	
3	Sustainability potential of CE and I4.0/Cleaner technology for renewable energy	5	4	3	5	4	5	4	5	5	4	5	5	4,50 Accept the link	
4	Sustainability potential of CE and I4.0/Resource availability and efficiency	4	3	2	4	3	4	4	3	4	4	5	4	3,67 Accept the link	
5	Sustainability potential of CE and I4.0/Resource flexibility	4	3	3	4	4	5	4	3	4	3	4	4	3,75 Accept the link	
6	Resource flexibility/ Green Infrastructure	5	4	5	5	4	4	5	5	4	5	5	4	4,58 Accept the link	
7	Resource flexibility/ Resource availability and efficiency	5	4	4	3	5	4	4	5	4	4	4	4	4,17 Accept the link	
8	Resource flexibility/ Sustainability potential of CE and I4.0	4	4	3	4	4	3	4	4	5	3	4	4	3,83 Accept the link	

(*continued*)

Table A2. Validation assessment of the TISM model

#	Paired comparison of enablers	1	2	3	4	5	6	7	8	9	10	11	12	Average score for each link	Average score for the model
9	Resource availability and efficiency/SC collaboration	5	3	2	4	3	4	4	3	4	2	4	3	3,42 Accept the link	
10	Resource availability and efficiency/SC connectivity	4	4	3	5	4	4	3	4	4	5	4	4	4,00 Accept the link	
11	Resource availability and efficiency/ Sustainability potential of CE and I4.0	4	3	3	4	2	3	4	4	4	4	5	4	3,67 Accept the link	
12	Cleaner technology for renewable energy/Green infrastructure	5	4	5	4	4	5	4	5	5	5	4	5	4,58 Accept the link	
13	Cleaner technology for renewable energy/Resource availability and efficiency	3	3	4	2	0	3	4	3	3	4	2	4	2,92 Reject the link	
14	Cleaner technology for renewable energy/ Sustainability potential of CE and I4.0	4	5	4	3	4	5	4	4	5	4	5	4	4,25 Accept the link	
15	SC connectivity/SC collaboration	5	5	4	5	4	4	5	4	5	5	5	5	4,67 Accept the link	
16	SC connectivity/ Innovation capacity	3	4	4	3	2	4	3	4	2	4	4	4	3,42 Accept the link	
17	SC connectivity/ Resource availability and efficiency	3	3	4	4	2	4	3	4	4	4	5	3	3,58 Accept the link	
18	Governmental support/SC collaboration	4	5	5	4	3	4	3	3	5	5	4	4	4,08 Accept the link	
19	Governmental support/Innovation capacity	5	5	4	5	4	4	4	5	5	4	5	4	4,50 Accept the link	
20	Governmental support/Green infrastructure	5	5	4	5	4	4	5	4	5	4	4	4	4,42 Accept the link	
21	Governmental support/SC connectivity	4	3	3	4	2	4	4	5	4	3	4	4	3,67 Accept the link	

Table A2. (*continued*)

#	Paired comparison of enablers	1	2	3	4	5	6	7	8	9	10	11	12	Average score for each link	Average score for the model
22	Governmental support/Cleaner technology for renewable energy	5	4	5	5	4	4	5	4	5	5	5	4	4,58 Accept the link	
23	Governmental support/ Sustainability potential of CE and I4.0	4	4	3	4	2	3	4	4	4	4	5	5	3,83 Accept the link	
24	Innovation capacity/SC connectivity	4	3	4	4	5	4	3	4	5	5	4	4	4,08 Accept the link	
25	Innovation capacity/Resource availability and efficiency	3	4	3	3	2	4	4	3	4	4	3	5	3,50 Accept the link	
26	SC collaboration/ Innovation capacity	4	4	4	3	3	3	4	4	4	5	4	4	3,83 Accept the link	
27	SC collaboration/ Resource availability and efficiency	3	3	4	2	0	3	4	3	3	4	2	4	2,92 Reject the link	
28	SC collaboration/ Sustainability potential of CE and I4.0	4	4	5	4	3	4	3	4	5	4	5	5	4,17 Accept the link	
29	Top management involvement/SC collaboration	5	5	4	4	5	4	5	5	5	5	5	5	4,75 Accept the link	
30	Top management involvement/ Innovation capacity	4	4	5	4	4	4	5	4	5	5	4	5	4,42 Accept the link	
31	Top management involvement/ Cleaner technology for renewable energy	4	3	4	4	5	3	4	4	3	4	4	4	3,83 Accept the link	
32	Top management involvement/ Resource availability and efficiency	3	4	4	5	4	3	4	5	4	4	3	3	3,83 Accept the link	
33	Top management involvement/ Resource flexibility	4	4	2	3	4	3	3	4	4	4	4	3	3,50 Accept the link	
34	Top management involvement/ Sustainability potential of CE and I4.0	4	3	4	5	4	4	4	5	5	4	4	3	4,08 Accept the link	

Table A2.