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Employing total quality practices in sustainable supply chain management

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ABSTRACT

The rapid development of Sustainable Supply Chain Management (SSCM) has resulted in several links and management techniques less explored to date. Thus, the integration of Total Quality Management (TQM) and Sustainable Supply Chain Quality Management (SSCQM) is an important intersection that needs further investigation. In this study, tools from TQM and resources from the resource-based view (RBV) theory are integrated into the sustainable supply chain setting. We employed a hybrid approach by combining grey-based Decision-Making and Trial Evaluation Laboratory (DEMATEL) and covariance-based Structural Equation Modelling (CBSEM) to create a model comprising of influential practices to analyse the interaction between practice and its effects on the implementation of SSCQM in the manufacturing industry. The analysis emphasises the interrelations as well as the level of importance of the identified resource components while proposing a model and testing it based on empirical data. Results revealed that cross-functional cooperation is effective on social issues, human resource management (HRM), the quality management system and supply chain capabilities. Also, social issues are effective on HRM, the environmental management system and customer focus. The quality management system is effective on HRM and supply chain capabilities. Supply chain capabilities impact customer focus and the environmental management system while HRM impacts environmental management systems. The developed model was initially validated and all interrelationships between the practices were accepted except the effect of HRM on environmental management system and the effect of social issues on HRM. This study assists practitioners in focusing on the core practices of managing resource consumption with regard to SSCQM.

1. Introduction

Environmental impact is a key focus in the discussion on sustainability performance in supply chains. This focus drives various stakeholders to pressure companies towards eco-friendly manufacturing and production processes, and reducing negative impacts on natural resources (Abbas and Sağsan, 2019). The population around the globe is expanding, and the resources are dwindling (Min and Kim, 2012). Thus, there is a need for a systematic perspective on sustainable resource uses along the supply chain (Abbas, 2020) to maintain the quality of life at an optimal level (Nandi et al., 2020). Total quality management (TQM) offers tools which systematically address processes that can boost the efficient use of resources (Abbas, 2020). Hence, focusing on TQM tools and their application in supply chains could improve sustainability performance (Bastas and Liyanage, 2019).

TQM aims to achieve efficient use of natural resources which is the core objective of environmental sustainability (Siva et al., 2016). It enhances product quality and improves the competitive advantage of organizations while minimising cost, delivery time and waste via efficient use of resources (Yusr et al., 2017). TQM integrates sustainability and supply chain management (SCM) by providing an integrated management system, managing stakeholders and focusing on customers (Siva et al., 2016), providing continuous improvement (Glover et al., 2015) and managing human resources (Vanichchinchai and Igel, 2011).

The focus on resources can further be explained through a theoretical lens such as the resource-based view (RBV). RBV views the effectiveness and efficiency of organizational performance as

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strongly dependent on its resources (Savino and Shafiq, 2018). In accordance with RBV, resources are valuable, rare, inimitable, and non-substitutable which leads the supply chain to gain competitive advantages (Nandi et al., 2020). In accordance with RBV, firms can harbour superior performance and competitive advantages through developing and deploying organizational resources (Yang et al., 2019). RBV is mostly used in research conducted in areas such as strategic and general management, production, operations, and SCM (Holweg and Pil, 2008). Arya and Lin (2007) supported the theory and demonstrated that organizations can enhance their capabilities and consequently get higher monetary and non-monetary rewards through mutual collaboration. Lai et al. (2012) showed that internal integration plays an important role in building customer and supplier integration which is consistent with theory. The prime aims of sustainability along supply chains are satisfying customer needs, green sourcing, green designing, green manufacturing, green distributing, and increasing the quality of end products (Tian et al., 2014). Focusing on sustainability may affect the supply chain resulting in material supply disruption, low quality of the end product, increased negative environmental impacts, utilization of extra resources and reduction of performance (Mangla et al., 2015). In this regard, comprehensive TQM systems can revamp organisational performance to overcome disruptions enabling the supply chain to meet customer needs, improve quality, and reduce the impact on environment and resources (Green et al., 2019). TQM is a key tool which considers the economic, ecological and social aspects. TQM has a high potential in seeking sustainability through establishing objectives and goals and supporting the triple bottom line for sustainable development (Zink, 2007). Therefore, it has a fundamental role in driving sustainable development. Bastas and Liyanage (2018) reviewed TQM, SCM and sustainability and concluded that there is synergy and potential in TQM, SCM and sustainability for performance enhancement. Their study captured a wide scope of SCM and its effects on sustainable development. Sustainable development has become a key stakeholder requirement for organizations. Using the best practices, models, and principles of management can accelerate the transition towards effective sustainable management (Kuei and Lu, 2013). Despite the importance of the integration of TQM, SCM and sustainability, the research stream has remained highly limited (Bastas and Liyanage, 2019). After a close examination of the literature addressing Sustainable Supply Chain Management (SSCM), specifically with the lens of RBV and TQM, we concluded that it is necessary to determine which resources and capabilities are significant for successful implementation of Sustainable Supply Chain Quality Management (SSCQM). Hence, our study aims to address this gap by extending the new concept known as SSCQM while introducing a critical set of resources and capabilities in order to increase the sustainability of organizations in the manufacturing industry. Moreover, this paper explores the important intersection between TQM and SSCM through the lens of RBV. The following are the research questions:

- What core resources are involved when implementing TQM in a sustainable environment?
- How are these core resources interrelated in a sustainable supply chain setting?

To answer the above questions, a hybrid approach consisting of the grey-based Decision-making Trial and Evaluation Laboratory (grey-based DEMATEL) method and covariance-based Structural Equation Modelling (CBSEM) were employed. Firstly, expert opinion was acquired via interview to complete the pairwise matrix of grey-based DEMATEL. The grey-based DEMATEL is employed in order to map the dimensions via their interrelationships. Secondly, we developed a questionnaire to gather data to test the model using CBSEM. CBSEM is employed to test the latent variables and judge the fitting model based on the structural model which is gained via grey-based DEMATEL.

The rest of the paper is organised as follows. In Section 2, the background of the study is discussed. Sections 3, –5, present the method, the results of grey-based DEMATEL and CBSEM and the discussion, respectively. The paper concludes with conclusions and suggestions for future research in Section 6.

2. Literature review

SSCM refers to the interrelations of three pillars, namely environment, society and economy, in a supply chain context which have equal importance and can be considered as an integrative theory of sustainability (Savino and Shafiq, 2018). The core role of SSCM is managing the flow of material, information, and resources in order to produce products and services to satisfy stakeholder, and especially customer, needs (Ahi and Searcy, 2013). In addition, SSCM can be implemented by meeting stakeholder demands and expectations for continuity of organisational performance (Beske and Seuring, 2014).

The literature focuses on different aspects of sustainability in supply chains. Qasrawi et al. (2017) have stressed that an organisation should connect its sustainable development goals with TQM practices. Angell and Klassen (1999) have shown that the TQM toolbox is an approach addressing different stakeholder needs, including customer expectations, in the supply chain. However, a small number of scholars have highlighted a negative relationship between TQM and sustainable performance as they consider it a formalized approach which hinders the creativity of an organization

(Li et al., 2018). Also, it has been indicated that TQM is a standard-oriented approach which focuses on current products rather than focusing on a unique solution for future products. Some scholars have showed a positive relationship and mutual reinforcement between TQM and sustainability stating that TQM focuses on internal and external customers resulting in improved product quality, differentiated products and increased on-time product delivery while improving sustainability performance along the supply chain (Abbas, 2020; Shahzad et al., 2020). However, Bastas and Liyanage (2018) did a systematic literature review and introduced a new concept named SSCQM while stating that TQM significantly influences the three pillars of sustainability and organisational performance.

2.1. Sustainable supply chain quality management

TQM tracks systematic excellence, efficiency and sustainability by continuous improvement of organizational policies, procedures and processes (Bastas and Liyanage, 2018). TQM can be expanded to include sustainable development components. TQM principles can lead the organization toward corporate sustainability by focusing on the triple bottom line dimensions. Studies integrating TQM, SCM and sustainability have been increasing since 2005 (Bastas and Liyanage, 2019).

Scholars have focused on different dimensions of TQM in the sustainable supply chain. For instance, Govindan et al. (2014) provided a model of TQM, resilience and green supply chain practices in order to achieve a sustainable supply chain focusing on waste elimination, TQM, just-in-time, cleaner production, flexible sourcing, risk management, flexible transportation, ISO 14,001 certification, and reverse logistics components. Jabbour et al. (2014) studied the relationships between TQM, SCM and sustainability demonstrating that quality management systems like ISO 9001, TQM and supplier quality certification have a positive relationship with each other and are crucial for environmental management.

Dubey et al. (2015) confirmed that supplier relationship management positively effects TQM and their interrelationships contribute to the environmental performance of organizations by focusing on leadership, TQM, supplier relationship management and environmental performance. Agi and Nishant (2017) discussed a positive relationship between quality management system (ISO9001) and green supply chain management (GSCM) principles by integrating certain components, namely technological capabilities, use of information technology, the capabilities of the purchasing department, company size, functional integration, top management commitment, employee education and training level, employee empowerment, involvement and incentives (reward and appraisal system), applying quality management principles, knowledge management and sharing, alignment of company strategy with purchasing strategy, monitoring performance, information and knowledge sharing with supply chain partners, assessing and monitoring supplier performance and practising supplier selection and integration with supply chain partners and formation of cross functional cross-company teams, trustful relationships with supply chain partners, dependence relationships with supply chain partners, and long-term relationships with supply chain partners. Abbas (2020) utilised the six dimensions of the Malcolm Baldrige National Quality Award (MBNQA), namely leadership, process management, strategic planning, customer focus, information and analysis and human resource management (HRM) to explore the relationships between TQM dimensions and corporate green performance while understanding their mutual impacts. Savino and Shafiq (2018) investigated the main sustainability drivers, which improve the production performance utilising RBV as the theoretical viewpoint of their study while analysing potential sustainability resources such as cross-functional cooperation, social issues, safety management, quality control, sustainability awareness, IT systems, and environmental management which act as strategic assets enhancing production performance.

Our study mainly follows the SSCQM model proposed by Bastas and Liyanage (2018). They presented a synergy between ISO9001 quality management principles along a sustainable supply chain with the triple bottom line where they suggested that further exploration was needed to verify and validate the relationships identified in their study. They conducted a survey and extracted 50 models integrating TQM, SCM and sustainability. They concluded that 34% of the models only focused on the integration of TQM and SCM and only 42% of the models had a holistic approach and considered all triple bottom lines of sustainability. Furthermore, their study highlighted the fact that only 4 models which utilized ISO9001 principles in their constructs focused on TQM, SCM and sustainability and among them only one of the models provided a positive relationship between TQM, SCM and triple bottom line sustainability. ISO9001 has seven fundamental constructs including, 'customer focus, leadership, engagement of people, process approach, improvement, evidence-based decision making and relationship management'. Although the importance of the ISO9001 principles have been noticed by different scholars (Agi and Nishant, 2017; Jabbour et al., 2014; Bastas and Liyanage, 2018), there are a number of other constructs which need to be mentioned in evaluating the economic, environmental and social aspects of sustainability. Therefore, a more comprehensive SSCQM model focusing on the resources and capacities of the supply chain is needed due to the competitive environment. Hence, this study explores different resources for SSCQM. Based on the extensive literature on RBV and sustainability, our study builds on seven main resources. RBV theory focuses on company capability that helps organizations to enhance their performance and gain competitive advantages (Al-Dhaafri and Alosani, 2020). Different scholars focus on different resources and capabilities (Al-Dhaafri and Alosani, 2020; Schoenherr, 2012; Tipu and Fantazy, 2018). In the current paper, the following resources and capabilities have been chosen in order to cover all aspects of sustainability in SSCQM: quality management system, customer focus, environmental management systems, cross-functional cooperation, supply chain capabilities, social issues, and HRM; this aims to analyse the role of TQM in SSCM. The following sections briefly discuss the identified resources, and the analytic categories of the study are summarised in Table 1.

2.1.1. Quality management system

The quality management system is a resource that is related to the international standard ISO 9001 and impacts production management, product and process quality and employee performance (Savino et al., 2017). For instance, it allows organisations to rapidly respond to environmental changes to improve productivity, meet customer demands, and reduce waste, cost and time. Successful implementation of the quality management system can be accomplished via employee engagement and empowerment, customer focus, continuous improvement, organisational training for TQM, and increased communication along the supply chain (Al-Dhaafri and Alosani, 2020).

2.1.2. Customer focus

Customers enhance a company's competitive advantage as they increase the visibility of information and knowledge on the market served by an organisation (Bastas and Liyanage, 2019). This boosts organisational performance and renders the company more agile in the market and in relation to environmental changes while contributing to the sustainability of a supply chain (Abbas, 2020; Al-Dhaafri and Alosani, 2020). Quality management practices are adopted to improve the quality of existing products and services which fulfil the demands of customers and other stakeholders while reducing waste (Abbas, 2020). In addition, focusing on the customers and coordinating with them increases their environmental awareness which, consequently, brings benefits and improves customer satisfaction (Wan et al., 2021).

2.1.3. Environmental management system

Environmental management systems are a major criterion for assessing sustainability in TQM. Environmental management system refers to providing a higher level of environmental control along the supply chain to be environmentally friendly. The environmental friendliness of a supply chain is comprised by the amount of carbon footprint and toxic emission and pollution of water, air and so on (Wan et al., 2021). In other words, an environmental management system focuses on preventing pollution, managing sustainable resource consumption and mitigating climate change for an eco-friendly environment (ISO26000, 2010).

2.1.4. Cross-functional cooperation

Internal cooperation between employer and employee can enhance synergy and improve lead time and productivity (Savino and Batbaatar, 2015). Moreover, it serves to integrate the sustainability goals of an organisation with its business strategy and management systems (Lo et al., 2018). Nandi et al. (2020) argue that internal cooperation is an operational capability which enables sharing information and knowledge with organisational units effectively and efficiently. Further, the authors emphasise that internal cooperation aligns organisational units with strategic planning. Ultimately, cooperation helps to align the upstream and downstream elements of the supply chain. Typically, supply chain cooperation is seen as a supply chain practice driving sustainable performance (Beske et al., 2014). This is complemented by cooperation between stakeholders along the supply chain, promoting learning and sharing knowledge and information to enhance environmental and social sustainability (Beske, 2012).

Table 1
Sustainable supply chain quality management components and the related indicators.

Sustainable supply chain management components	Indicators	References
Quality management system (E1) Refers to developing different practices in order to enhance corporate performance. It focuses on human resource involvement, customer focus and continuous improvement.		(Abbas, 2020; Savino and Shafiq, 2018; Agi and Nishant, 2017; Andres-Jimenez et al., 2020; Armstrong and Shimizu, 2007; Savino et al., 2017)
Improving product quality	QM1	(Abbas, 2020; Savino and Shafiq, 2018; Andres-Jimenez et al., 2020; Dubey et al., 2015)
Worker awareness of quality policies	QM2	(Abbas, 2020; Savino and Shafiq, 2018)
Long term objectives for quality improvement	QM3	(Abbas, 2020; Savino and Shafiq, 2018; Andres-Jimenez et al., 2020)
Consuming the least amount of resources, such as water, electricity and gas	QM4	(Abbas, 2020; Savino and Shafiq, 2018; Ahi and Searcy, 2013)
Customer focus(E2) Customers are the users of final products and services and their opinions, such as their complaints or satisfactions about the products and services, directly affect the profit, cost, and reputation of the organization. Hence, focusing on the customers and collaborating with them greatly affects the sustainable survival and development of the firms along the supply chain		(Abbas, 2020; Al-Dhaafri and Alosani, 2020; ISO9001, 2015; ISO26000, 2010)
Understanding the current and future needs of customers	CF1	(Abbas, 2020; Al-Dhaafri and Alosani, 2020)
Linking the objectives of the organisation to customers	CF2	(Abbas, 2020; Al-Dhaafri and Alosani, 2020)
Sustainable consumption (Green consumer attitude)	CF3	(Luthra et al., 2017; Rajeev et al., 2017)
Environmental management system (E3) Environmental management system refers to providing higher levels of environmental control along the supply chain to be environmentally friendly.		(ISO26000, 2010; Rahdari and Rostamy, 2015)
Improving energy efficiency	ES1	(Abbas, 2020; Abbas and Sağsan, 2019; Tipu and Fantazy, 2018; Wan et al., 2021)
Preventing pollution	ES2	(Dubey and Gunasekaran, 2015; Schoenherr, 2012; Tipu and Fantazy, 2018; Walker and Jones, 2012; Jabbour et al., 2014, Wan et al., 2021)
Protecting the environment and restoration of natural habitats	ES3	(El-Berishy et al., 2013; Faccio et al., 2014; Tipu and Fantazy, 2018; Wan et al., 2021)
Cross-functional cooperation (E4) Cross-functional cooperation represents three perspectives, namely firm internal cooperation, upstream supplier cooperation, and downstream customer cooperation		(Grekova et al., 2016; Tipu and Fantazy, 2018; Agi and Nishant, 2017; Lo et al., 2018)
Information exchange and teamwork	CC1	(Al-Dhaafri and Alosani, 2020; Nandi et al., 2020; Savino and Shafiq, 2018; Agi and Nishant, 2017)
Cross-functional cooperation between different areas	CC2	(Savino and Shafiq, 2018; Tipu and Fantazy, 2018; Wan et al., 2021)
Supplier relationship management	CC3	(Dubey et al., 2015; Savino and Shafiq, 2018; Tipu and Fantazy, 2018; Agi and Nishant, 2017; Caniato et al., 2012)
Supply chain capabilities (E5) Supply chain capabilities are intangible resources which provide a comprehensive platform for the organisations to align their resources and processes to achieve continuous improvement in outcomes.		(BS8900, 2013; ISO9001, 2015; Wan et al., 2021), (Glover et al., 2015)
Information sharing capabilities	SC1	(Bi et al., 2013; Sanders, 2008; Wu et al., 2006; Wan et al., 2021; Hosseini et al., 2019)
Coordination capabilities	SC2	(Bi et al., 2013; Sanders, 2008; Wu et al., 2006; Wan et al., 2021)
Integration capabilities	SC3	(Bi et al., 2013; Wu et al., 2006; Yu et al., 2017; Wan et al., 2021)
Social issues (E6) Social issue efforts are crucial to SSCM as ethical, and social practices increase organisational competitive advantage while reaching sustainable development goals.		(ISO26000, 2010; Turner et al., 2019; Abbas, 2020)
Fair competition	SI1	(Lazuras et al., 2011; Luthra et al., 2015)
Promoting social responsibility in the value chain	SI2	(Beske and Seuring, 2014; Diabat et al., 2014; Jia et al., 2015; Turner et al., 2019)
Respect for property rights, ethics and social equity	SI3	(ISO26000, 2010; Savino and Shafiq, 2018; Tipu and Fantazy, 2018; Wan et al., 2021; Turner et al., 2019; Rahdari and Rostamy, 2015)
Human resource management(E7) Human resource management focuses on the employees in organizations by enhancing employee development via training and employee empowerment achieved by an employee performance recognition system.		(Al-Dhaafri and Alosani, 2020; Turner et al., 2019)
Employment relationships	HR1	(Abbas, 2020; Andalib Ardakani and Soltanmohammadi, 2018; Beske and Seuring, 2014; Walker and Jones, 2012)
Health and safety and social protection at work	HR2	(Abbas, 2020; Jia et al., 2015; Kleindorfer et al., 2005; Tipu and Fantazy, 2018; Azadnia et al., 2015)
Human development and training in the workplace	HR3	(Abbas, 2020; Lozano, 2013; Turner et al., 2019; Azadnia et al., 2015; Agi and Nishant, 2017)
Providing financial support to workers (e.g. payable salary)	HR4	(Abbas, 2020; Savino and Shafiq, 2018; Agi and Nishant, 2017; Rahdari and Rostamy, 2015)

2.1.5. Supply chain capabilities

Supply chain capabilities are one of the most important issues for researchers and practitioners. A number of studies have focused on such capabilities (Wan et al., 2021). Improving supply chain capabilities helps the supply chain to benefit from competitive advantages in a dynamic environment and different capabilities are prerequisites for supply chain survival (Wan et al., 2021).

These capabilities are obtained via integration, collaboration, and coordination techniques (Nandi et al., 2020). Integration plays a major role in supply chains in reducing supply chain performance and cost and improving customer services. Moreover, integration encourages inter-organisational relationships by expanding information sharing (Lo et al., 2018). Information sharing promotes inter- and intra- organisational knowledge and information sharing while improving supply chain visibility and efficiency (Nandi et al., 2020).

2.1.6. Social issues

To improve social sustainability, organisations need to deploy the best practices in utilising resources such as time and funds to enrich employee values and self-esteem while respecting fair-trade policies and consumer rights (Abbas, 2020). Social issue programs not only increase reputation, but also enhance customer satisfaction and commitment (Islam et al., 2019). Maignan and Ferrell (2000) argued that social issue actions can be divided into four groups, namely social issue efforts for consumers, the government, employees and stakeholders. Social issues for the customer/consumer refers to supply chain responsibilities toward consumers e.g. offering good prices (Abbas, 2020), providing fair transaction fulfilment (Luthra et al., 2015), respecting consumer complaints and suggestions (Abbas, 2020) and promoting social responsibility in the value chain (Savino and Shafiq, 2018).

2.1.7. Human resource management

HRM focuses on the employees in the organizations (Turner et al., 2019). Inyang et al., p.118) note that HRM contains tasks including "leading and educating employees on the value of corporate social responsibility (CSR), developing responsible and sustainable practices, communicating CSR activities to employees and other stakeholders, and providing direction, control and action plans for implementing leadership for and education of employees in the organization." Moreover, HRM strengthens the relationship between employer and employee by educating employees on their responsibilities while ensuring their occupational health and safety (Abbas, 2020; Andalib Ardakani and Soltanmohammadi, 2018; Savino and Shafiq, 2018). In a sustainability perspective, HRM contributes by training employees and other stakeholder members to increase the awareness of sustainable performance and its contribution to society (Hao et al., 2020).

3. Methods

The research is conducted in two phases. In the first phase, the components relevant to resources in SSCM based TQM are identified via interview. In the second phase, ranking, determining the cause-effect interrelationship of the components, and testing the model is done using the hybrid grey-based DEMATEL and CBSEM approaches with the data collected via survey. Meng (2014) conducted a survey and compared CBSEM and DEMATEL and the results showed that both methods are used to study factor structure patterns. Furthermore, the authors concluded that integrating both methods assists in determining model specification, model fitting, model assessment, model modification and result explication. Liao and Chen (2020) also conducted a survey and concluded that both DEMATEL and SEM have advantages and combining the two methods is a good research strategy and improves the accuracy of the research results. They demonstrated that DEMATEL can be used to gather expert opinion and provide a model of the factors. By assessing the literature, we operationalized a combined approach consisting of grey-based DEMATEL and SEM as shown in Fig. 1 in order to answer the research questions and achieve the study goals.

The hybrid approach has several benefits. Firstly, the priority of the components and the degree of their cause and effect will be determined. Secondly, interrelationships among the components can be developed and their structural model presented. Thirdly, the model can be tested to determine how it would help in improving decision-making.

3.1. Grey-based DEMATEL technique

DEMATEL is the technique as proposed by Gabus and Fontela (1972). It works based on the graph theory and matrices and is used to establish causal relationships among the components (Yin et al., 2020). It is a method which can be applied to companies facing issues which require group decision making (Bai and Sarkis, 2013). In practice, there is contradiction in the decision-making process because of human bias and unclear information. To overcome such a problem, fuzzy concepts can be integrated with DEMATEL. However, fuzzy based DEMATEL is incapable of drawing a membership function. As a result, grey set theory can be used with DEMATEL to evaluate and map the interrelationships between components and overcome decision bias resulting from human involvement (Luthra et al., 2020). Hence, grey-based DEMATEL is much used in different studies (see Table 2). Grey-based DEMATEL is a comprehensive technique to build and analyse the causality of a structural model through matrices or digraphs between components (Azar and Ardakani, 2014). This technique is used to identify the inter-influence between the identified components and measure their interrelations (Jia et al., 2015). Moreover, it simplifies the problem and provides a map of interaction among the components based on expert opinion through a pairwise matrix (Zhu et al., 2011).

3.2. Covariance-based SEM technique

SEM is one of the most important methods of empirical research. SEM is used to do maximum-likelihood and co-variance analysis (Reinartz et al., 2009). CBSEM is used to test confirmatory models (Henseler, 2010). In a confirmatory model, the researcher formulates a model and tries to test the model via empirical data in order to accept or reject it. In the current paper, the focus of the research is on confirming the assumed relationships. Hence, CBSEM is used in order to test the model. CBSEM is a prediction-orientated approach and applies prediction errors to measure the accuracy of prediction (Sanchez, 2013). CBSEM assesses two parts of a model: (a) the internal consistency or reliability of the measurement model outer mode, convergent validity, and discriminant validity; (b) the structural model or inner model. We used software including SPSS v.23 and AMOS v.23 for the analysis.

3.3. Research methodology

In the first step, we developed a model of components and illustrated the causal relationships between the identified components related to TQM and SSCM using the grey-based DEMATEL technique. We used pairwise matrices within the grey-based DEMATEL technique to determine the causal relationships among the components. In this regard, the opinion of industry experts was obtained using a five-level grey scale.

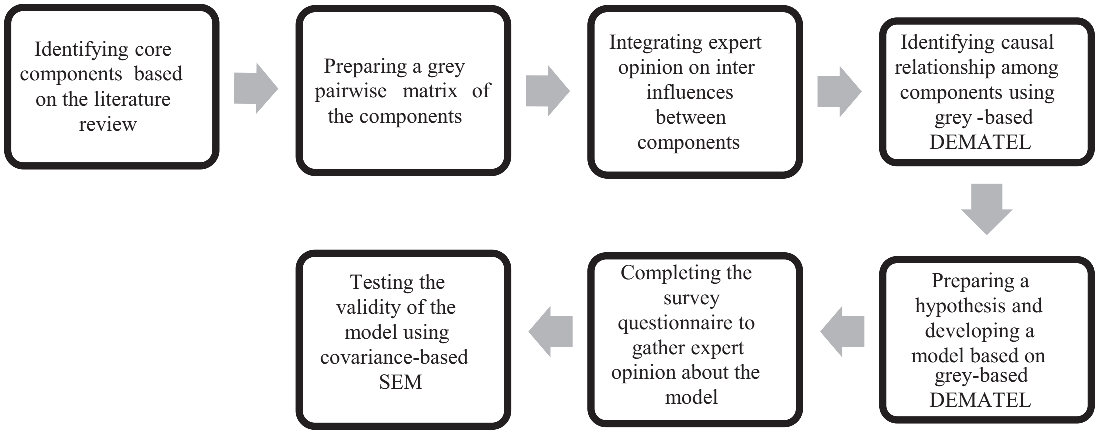

Fig. 1. Research methodology.

Table 2
Applications of grey-based DEMATEL technique reported in the literature.

No.	Source	Description
1.	(Bai and Sarkis, 2013)	Evaluated the business process management success factors
2.	(Shao et al., 2016)	Analysed the barriers taking aspects of ecologically driven products and consumers: practitioners' contexts
3.	(Luthra et al., 2018)	Modelled the critical success factors for sustainable supply chains
4.	(Bouzon et al., 2018)	Evaluated reverse logistics adoption
5.	(Luthra et al., 2020)	Examined the drivers to diffuse sustainability in supply chains

The grey scales ranged from "very low influence" to "very high influence" and the values of the scale were as follows: very low influence [0.0.2], low influence (0.2,0.4], moderate influence (0.4,0.6], high influence (0.6,0.8], very high influence (0.8,1]. There Grey-based DEMATEL technique divides the components into two groups namely cause and effect, and reveals causal relationships between them (Gardas et al., 2018). Hence, this paper follows the steps proposed by Gardas et al. (2018). Following are the main steps of the procedure, and the steps are discussed in detail in Appendix **A**.

- Step 1: Gathered the weighted and aggregated data based on expert opinion (see Table C.1).
- Step 2: Calculated the normalised grey-relation matrix N based on the overall grey direct relation matrices (see Table C.2).
- Step 3: Determined the total relation matrices among the components which shows their mutual effects (see Table C.3).
- Step 4: Determined the overall importance or prominence (Pi) of component i and net cause/effect (Ei) of component i (see Table C.4).

In the second step, hypotheses were developed based on the results of the first step and tested using CBSEM. A survey was conducted to gather data to test the model developed in this step.

3.4. Case example and data collection

The participants were experts from companies in the automobile, metal, textile, ceramic tile, and food industries in Iran. The chosen industries are the major ones in Iran's economy and consume most of its resources. The experts' opinions were obtained in two phases. In the first phase, we invited and gathered seven experts from the chosen industries in order to complete the pairwise matrix of grey-based DEMATEL (Table 3). The criteria for choosing the respondents in the sample were (1) having direct or indirect contact with production management activities and (2) being in a management position or having influence in their field. The expert group included a number of managers/supervisors from the above mentioned industries.

In the second phase, we developed a questionnaire (Appendix B) to gather data in order to test the model using CBSEM. The survey questionnaire was presented as an online and paper questionnaire and distributed amongst the experts via email, face to face and telephone interaction. The respondents had to rate the questionnaire on a five-point scale. The scale description was "5= Strongly agree, 4= Agree, 3= Neutral, 2= Disagree, 1= Strongly disagree". We sent the questionnaire to 570 experts and received different numbers of responses from the selected industries. Incomplete responses were discarded, and the CBSEM model was run with 475 completed questionnaires (see Table 4). Of the 475 responses, 63% had been completed by men and 37% by women. The majority of the respondents (44%) were at a bachelor degree level of education which was followed by a master's degree. Also, 56% of the respondents had 5–10 years of work experience.

4. Results

4.1. Output of the grey-based DEMATEL technique

This section presents the results obtained from the grey-based DEMATEL technique (Appendix **C**). Fig. 2 illustrates the cause and effect diagram. (D+R) is the horizontal axis vector named "prominence" which shows the importance of the components. In other words, the value of the horizontal axis (D+R) signifies the relative importance of a practice. The value of the vertical axis vector (D-R) signifies the cause or effect category. If (D-R) is positive, the practice is considered as being in the cause category, and in the case of a negative value for the (D-R), the practice is considered as belonging to the effect group (see Table 5). Thus, the causal diagram can be mapped using the data set (D+R, D-R) shown in Fig. 2. As seen in the figure and Table 5, supply chain capabilities (E5) has the highest (D+R) score. So, it should be considered as a relatively important component of SSCQM. It highlights the fact that different capabilities contribute to the supply chain in improving sustainability. E5 is followed by HRM (E7), environmental management system (E3), social issues (E6), cross-functional cooperation

Table 3
Expert selection process in phase 1.

Experts' job position	Number of experts	Functional area	Position in supply chain
Production manager	2	Production	Focal company (manufacturer)
National sales manager	2	Sales	Focal company (manufacturer)
Quality supervisor	2	Quality control	Focal company (manufacturer)
Retail sales manager	1	Dealer sales	Dealer

Table 4
Descriptive statistics of responses in phase 2.

		Gender		Level of education					Work experience(number of years)		
Industry	Number of respondents	Men	Women	Diploma	Assistance	Bachelor	Master	Doctorate	≤ 5	5–10	≥ 10
Automobile	91	52	39	10	13	40	25	3	20	58	13
Metal	96	54	42	13	15	38	28	2	16	61	19
Textile	99	68	31	14	15	41	27	2	25	56	18
Ceramics and Tile	94	64	30	17	15	44	17	1	30	48	16
Food	95	61	34	14	20	47	13	1	33	41	21
Total	475	299	176	68	78	210	110	9	124	264	87
percent	100%	63%	37%	14%	16%	44%	23%	3%	26%	56%	18%

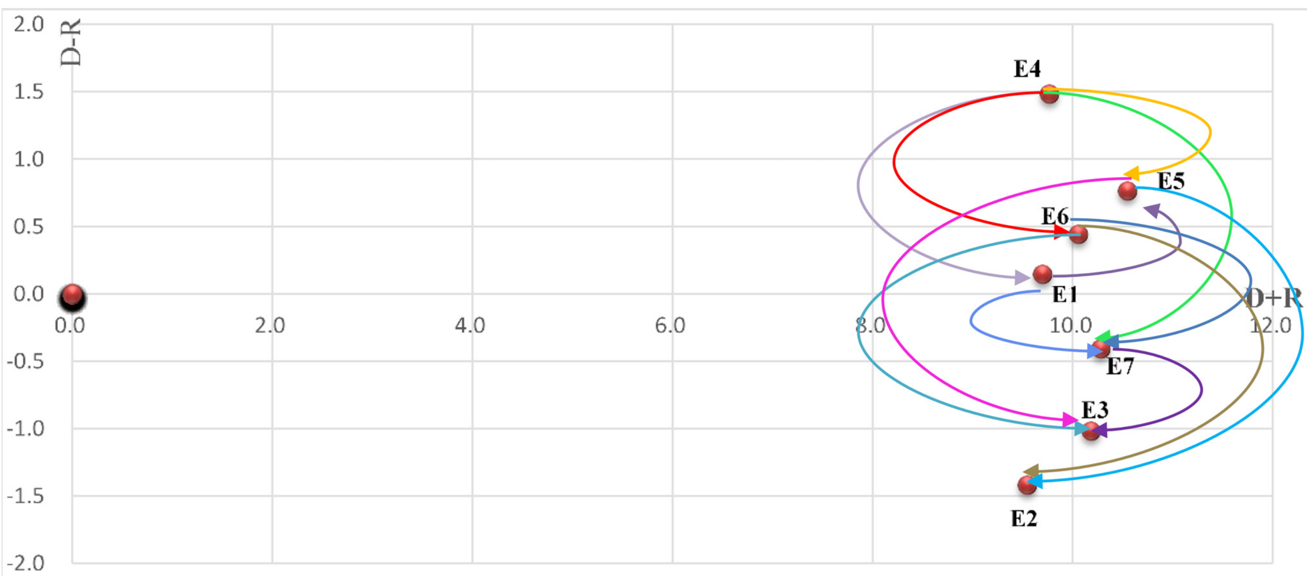

Fig. 2. Cause and effect components' diagram.
E1: Quality management system E2: Customer focus E3: Environmental management system E4: Cross-functional cooperation E5: Supply chain capabilities E6: Social issues E7: HRM.

Table 5
The prominence and the related vectors.

Components	D_i	R_i	$(D + R)$	$(D + R)$ ranking	(D-R)	(D-R)ranking
E1	4.9	4.8	9.7	6	0.1	4
E2	4.05	5.45	9.5	7	−1.4	7
E3	5.05	5.15	10.2	3	−0.1	5
E4	5.65	4.15	9.8	5	1.5	1
E5	5.65	4.85	10.5	1	0.8	2
E6	5.25	4.85	10.1	4	0.4	3
E7	4.95	5.35	10.3	2	−0.4	6

(E4), quality management system (E1) and customer focus (E2) in this group.

On the one hand, the value of the vertical axis (D-R) signifies that HRM (E7), environmental management system (E3) and customer focus (E2) are categorized in the effect group. This means that they are influenced by the other practices, as their (D-R) scores are negative. In other words, the influential impact (D) of these practices is less than their influenced impact (R). On the other hand, the cause group contains supply chain capabilities (E5), social issues (E6), cross-functional cooperation (E4) and quality management system (E1) which impact other practices and should be given more attention. In other words, these components have more influential impact (D) than influenced impact (R). Among the components of the effect group, the customer focus (E2) value is −1.4, which is the smallest value amongst the effect factors. This means that customer focus is obviously impacted by other components. In addition, among the cause group components, the cross-functional cooperation (E4) value is 1.5, i.e. the biggest value in

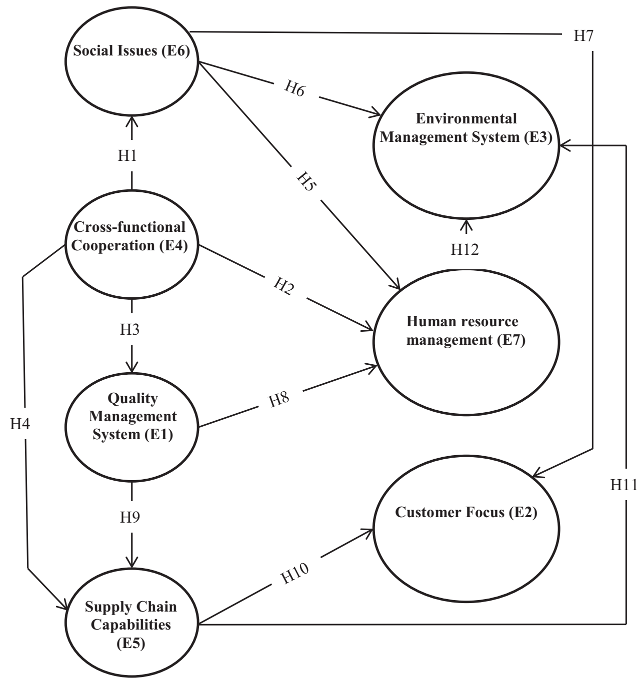

Fig. 3. Path Model based on grey-based DEMATEL.

the cause group. This means that it has the highest impact on the other components. Hence, in (D-R) ranking, cross-functional cooperation (E4), supply chain capabilities (E5), social issues (E6), quality management system (E1), environmental management system (E3), HRM (E7) and customer focus (E2) are ranked in order of importance respectively.

The final step of the grey-based DEMATEL technique shows the causal relationships among the components. The diagram, i.e. the Impact Relationship Map (IRM), demonstrates the inter-influence between the components in Fig. 2. The threshold value to identify the inter-influence is calculated as the mean of the component plus the standard deviation in the total relation matrices (see Table C.3). In this case, the threshold value is 0.8, and every component meeting this requirement was considered for the causal diagram. The results of the grey-based DEMATEL were used to develop the hypotheses for subsequent evaluation as shown in Fig. 3.

Fig. 2 shows that cross-functional cooperation (E4) is effective on quality management system (E1), supply chain capabilities (E5), social issues (E6), and HRM (E7). Cross-functional cooperation (E4) refers to the internal cooperation between different business units which creates more commitment and motivation to oblige TQM standards when meeting customer needs and eliminating social matters (Savino and Shafiq, 2018). Moreover, it creates awareness in terms of the needs and preferences of human resources.

Quality management system (E1) is effective on supply chain capabilities (E5) and HRM (E7). Quality management system (E1) refers to improving product quality on a short- and long-term basis while consuming fewer resources. Therefore, organisations might operationalise different strategies to achieve different objectives such as sharing information and knowledge with human resources and coordinating and integrating with other stakeholders of their supply chain (Shafiq et al., 2019).

The social issues component (E6) is effective on customer focus (E2), environmental management system (E3) and HRM (E7) as the social responsibilities in the value chain and which are needed to procure respect for social ethics and legal rights since they influence the organisational strategies of customer services, employee relationships and the workplace environment (Gorski, 2017). Furthermore, organisations link their objectives to align with customer needs and to reduce pollution while maximising energy efficiency (Gorski, 2017).

HRM (E7) is effective on the environmental management system (E3). It is self-explanatory, as the financial and social support provided by human resources helps sustain environmental protection (Abbas, 2020). The supply chain capabilities component (E5) is effective on customer focus (E2) and environmental management system (E3). It is explained in terms of capabilities such as integration, coordination or collaboration with different stakeholders of a supply chain which enable information and knowledge sharing as regards customer needs and preferences while maintaining environmental sustainability throughout the supply chain (Beske, 2012).

These relationships are discussed in Fig. 2 and were the tested in the industry section during the second step of this study. Fig. 3 shows the path model, including hypotheses tested using CB-SEM. Hence, following are the hypotheses considered.

H1: Cross-functional cooperation (E4) positively impacts social issues (E6).

Cross-functional cooperation is defined as the mutual interaction of members of different parts of organizations. Such interdepartmental meetings play a critical role in solving different concerns. For example, Stock et al., 2014 demonstrated that cooperation enables organizations to share information about customer needs for promoting social responsibility and consequently providing various managers with the sufficient information as regards the technical feasibility of solving problems.

H2: Cross-functional cooperation (E4) positively impacts HRM (E7).

Cross-functional cooperation encourages employees to cooperate with other departments and open up new channels with their counterparts which leads to cross-functional team activities (Zhou and Velamuri, 2018). Zhou and Velamuri (2018) concluded that cross-functional cooperation is an important enabler of fostering innovative employee behaviour because it fosters learning.

H3: Cross-functional cooperation (E4) positively impacts quality management system (E1).

Cross-functional cooperation refers to the internal cooperation between different units and teamwork among employees. This creates more commitment and motivation for meeting current and future customer needs and eliminating social problems (Savino and Shafiq, 2018). In addition, supplier relationship management promotes the involvement of suppliers in decision making, technological development and, consequently, meeting customer needs and expectations. Cooperation includes appropriate information and risk sharing in different areas (Dubey et al., 2015).

H4: Cross-functional cooperation (E4) positively impacts supply chain capabilities (E5).

Wan et al. (2021) demonstrated that supply chain cooperation and teamwork provides opportunities for changing products, services, processes, technologies and organizational resources. Such improvement in the supply chain capabilities creates value for all stakeholders and increases capacity development.

H5: Social issues (E6) positively impacts HRM (E7).

Social issues are described as the social sustainability of the supply chain. This refers to identifying and engaging with concerns along the supply chain including those of upstream and downstream firms. The social issues component is concerned with fair competition in the supply chain, respect for human rights and ethics and social responsibilities. Such practices require the cooperation of employees and other stakeholders and enable them to solve their problems (Gorski, 2017; Wan et al., 2021).

H6: Social issues (E6) positively impacts environmental management system (E3).

Promoting social responsibility in the value chain, social equity and respect for social ethics and rights enhances attention to the environment. It potentially decreases pollution and increases the efficiency of energy usage (Gorski, 2017).

H7: Social issues (E6) positively impacts customer focus (E2).

Social issues such as promoting social responsibility in the value chain, or respecting property rights, ethics and social equity positively affects the image of the firms along the supply chain through word-of-mouth advertising and building customer loyalty. Customers become aware of the responsible and irresponsible measures taken by organizations which influence the public's perceptions through word-of-mouth advertising and the media (Turner et al., 2019).

H8: Quality management system (E1) positively impacts HRM (E7).

Quality management system improves organizational performance by focusing on HRM practices (Salim et al., 2019). HRM improves the expertise of employees by using benefits and compensation, training and education, communication with employees, and employee development at the individual, team, organizational and social levels (Arshad Ali, et al., 2020).

H9: Quality management system (E1) positively impacts supply chain capabilities (E5).

Quality management system improves product quality on a short- and long-term basis and consumes the least amount of resources. To do so, the firms might use different strategies to reach their goals including sharing information and knowledge with employees or coordinating and integrating with other parts of the supply chain (Shafiq et al., 2019). In addition, implementing a quality management system such as ISO 9001 or ISO 14,001 has positive effects on the achievement of the coordination capability between supply chain partners to be environmentally sustainable (Agi and Nishant, 2017).

H10: Supply chain capabilities (E5) positively impacts customer focus (E2).

Different capabilities like integrating, coordinating or collaborating with different parts of the supply chains results in sharing information and knowledge about the customers' needs and preferences (Beske, 2012).

H11: Supply chain capabilities (E5) positively impact the environmental management system (E3).

Supply chain capability is a prerequisite for developing sustainability along the whole supply chain. The overall value of the supply chain is created by integrating, cooperating and coordinating the main members of supply chains including suppliers, consumers and focal companies. They are the important stakeholders that affect the sustainable performances of the supply chain including improving resource efficiency and protecting the environment (Dubey et al., 2015; Wan et al., 2021). Also, dissemination and information sharing about the environment between different partners in the supply chain facilitates the protection of the environment and the restoration of natural habitats (Agi and Nishant, 2017).

H12: HRM (E7) positively impacts environmental management systems (E3).

HRM practices can affect social issues by promoting social responsibility. As a result, human resources highlight the value of social responsibility and respecting social ethics, developing sustainable practices like protecting the environment and the natural habitat. Also, human resources provide direction, control and action plans for implementing sustainable programs in organizations. Hence, HRM grants a valuable contribution to organizational initiatives such as social responsibility or environmental management issues (Turner et al., 2019). In other words, educating employees about the environmental aspects of organizational activities and involving employees in the use of incentive programs encourages the development of methods and initiatives of supporting the environment (Agi and Nishant, 2017).

4.2. Results of covariance-based structural equation modelling

4.2.1. Results of measurement model evaluation

The measurement model evaluation analyses the relationship between the components and their items and was tested through confirmatory factor analysis (CFA). CFA was conducted to evaluate reliability and validity (Hinkin, 1998). We specified a 7-factor model where every indicator loads on its respective construct and the constructs are allowed to correlate. Overall, the model provides a good fit for the data (Chi sq /df = 1.52, GFI =0.943, AGFI= 0.925, NFI= 0.797, RMSEA =0.033).

Internal consistency reliability was assessed using composite reliability values (see Table 6) above the established threshold of 0.8 (Grekova et al., 2016). Also, Cronbach alpha values were evaluated (Peterson, 1994) and were all above 0.7.

Convergent validity is expressed by the average variance extracted (AVE) (see Table 6). It shows the proportion of the variance captured by the construct as opposed to the proportion of variance attributed to the measurement error. Molina et al. (2007) suggest that the average variance extracted (AVE) should be higher than 0.5 and all the values met this threshold.

Discriminant validity refers to the conceptual and empirical distinction of constructs. There are different ways to ensure that constructs are different from each other. In the current study, discriminant validity was examined using the ratio of HTHM/MTHM (Heterotrait -Heteromethod/ monotrait-heteromethod). In our case, the ratio was below the threshold value of 0.85, thus establishing discriminant validity.

Common method variance (CMV) is tested using Harman's Single-Factor. This test is conducted using principal component analysis (PCA). The first factor captured only 14.847% of the variance in the data versus a threshold value of 0.5, i.e. no single factor emerged, and the first factor did not capture most of the variance. This demonstrates that CMV was not a problem in this study.

4.2.2. Results of structural model evaluation

After assessing the measurement model fitness, the structural model was estimated. The results of different criteria yielded a good fit (Chi sq /df = 1.747, GFI =0.933, AGFI= 0.915, NFI= 0.755, RMSEA =0.040).

After accepting the quality of the model in its entirety, we were able to check the results of the hypotheses (See Table 7). To do so, the results of the regression equations estimate were calculated. They show that some hypotheses were supported while others were not. Hence, cross-functional cooperation (E4) is effective on HRM (E7) (3.265), supply chain capabilities (E5) (2.807), quality management system (E1) (2.365) and social issues (E6) (2.437). Cross-functional cooperation can be achieved through regular interdepartmental meetings. Such cooperation brings competitive advantages in the supply chain and significantly reduces risk and uncertainty. Vachon and Klassen (2008, p.300) stated that the "value of collaboration in the supply chain comes from the possibility of inter-organizational learning". In addition, they said that such cooperation increases awareness of the components, ingredients and working conditions of human resources in all the stages of the supply chain in order to achieve sustainability. Golicic and Smith (2013) found that such cooperation increases supply chain capabilities through supply chain partner integration and product development because supply chain capabilities are the source of competitive advantages in a dynamic environment. Savino and Shafiq (2018) discussed that cross-functional cooperation refers to internal cooperation among employees, which increases information sharing and employee awareness of quality

Table 6
Validity and reliability measures.

Latent constructs	Indicators	Standard Loading	Composite Reliability	AVE
Quality management system (E1)	QM1	0.50	0.99	0.99
	QM2	0.726		
	QM3	0.327		
	QM4	0.286		
Customer focus(E2)	CF1	0.451	0.94	0.98
	CF2	0.614		
	CF3	0.45		
Environmental management system (E3)	ES1	0.592	0.985	0.995
	ES2	0.717		
	ES3	0.514		
Cross-functional cooperation (E4)	CC1	0.491	0.953	0.984
	CC2	0.518		
	CC3	0.542		
Supply chain capabilities (E5)	SC1	0.392	0.994	0.997
	SC2	0.651		
	SC3	0.708		
Social issues (E6)	SI1	0.364	0.815	0.918
	SI2	0.66		
	SI3	0.236		
HRM (E7)	HR1	0.529	0.915	0.976
	HR2	0.701		
	HR3	0.605		
	HR4	0.466		

Table 7
Hypotheses testing results.

Hypothesis No.	Hypothesis relationship	T value	p	Results
H1	Cross-functional cooperation -> Social issue	2.437	0.015	supported
H2	Cross-functional cooperation -> HRM	3.265	0.001	supported
H3	Cross-functional cooperation -> Quality management system	2.365	0.018	supported
H4	Cross-functional cooperation -> Supply chain capabilities	2.807	0.005	supported
H5	**Social issue -> HRM**	**−0.278**	**0.781**	**unsupported**
H6	Social issue -> Environmental management system	2.606	0.009	supported
H7	Social issue -> Customer focus	2.283	0.022	supported
H8	Quality management system -> HRM	3.376	***	supported
H9	Quality management system -> Supply chain capabilities	3.834	***	supported
H10	Supply chain capabilities -> Customer focus	5.012	***	supported
H11	Supply chain capabilities -> Environmental management system	2.417	0.016	supported
H12	**HRM -> Environmental management system**	**0.505**	**0.614**	**unsupported**

*** $P<0.01$.

improvement in products and effective resource utilisation. Moreover, Yang (2016) demonstrated that cross-functional cooperation improves supply chain capabilities by maintaining a seamless flow of decisions, information, materials, goods and services to end customers/consumers. Hong et al. (2018) determined that cross-functional cooperation, especially vertically coordinated governance has an effect on the dynamism and complexity of the supply chain while providing an opportunity to adjust supply chain performance based on social, environmental and economic benefits.

The supply chain capabilities component (E5) impacts the environmental management system (E3) (2.417) and customer focus (E2) (5.012). Supply chain capabilities lead the supply chain to sustainability through communication and integration. Also, such capabilities contribute to sustainability through product development in line with environmental and social standards (Beske and Seuring, 2014). Agi and Nishant (2017) demonstrated that dissemination and information sharing capability concerning the environment between different partners in the supply chain facilitates protecting the environment and the restoration of natural habitats. The results are in line with the arguments of Masteika and Čepinskis (2015) as they found that supply chain capabilities enhance the agility of the supply chain when adapting to environmental changes. Beske (2012) found that supply chain capabilities improve the flexibility of a supply chain which allows swift and easy coordination relative to market changes and meeting customer needs, and ultimately achieves sustainability.

The social issues component (E6) impacts the environmental management system (E3) (2.606), and customer focus (E2) (2.283) but is not effective on HRM (E7) (−0.278). Social issues, described as the social sustainability of the supply chain, refer to identifying and engaging with concerns along the supply chain including those of upstream and downstream firms, and the internal workings of focal firms (Gorski, 2017; Wan et al., 2021). The results are in line with Raimi (2017) who defined social issues as the social responsibility of organisations. Moreover, it was identified as a green strategy which preserves the social aspect of the environment. Gorski (2017) emphasised that social responsibility measures improve organisational capability geared towards sustainable growth objectives. Such practices not only increase organisation reputation but also enhance customer loyalty and employee satisfaction. Also, Turner et al. (2019) found that customers are aware of their rights and the social equity of the supply chains will increase customer loyalty and a positive image of the organization will be created by word-of-mouth. Furthermore, addressing social issues will increase market share while reducing emissions, waste and pollution (Awan et al., 2017; Turner et al., 2019).

Quality management system (E1) is effective on HRM (E7) (3.376) and supply chain capabilities (E5) (3.834). Quality management systems are about improving product quality for short term and long-term periods and consuming the least amount of resources and using different strategies to reach their goals (Shafiq et al., 2019). Arshad Ali, et al. (2020) confirmed that HRM improves organizational performance through enhancing employee experience, improving communication with employees and enhancing their compensations, training and educational level. Also, Agi and Nishant (2017) concluded that implementing quality management systems such as ISO 9001 or ISO 14,001 has a positive effect on the achievement of the coordination capability between SC partners to be environmentally sustainable. Shafiq et al. (2019) revealed that a quality management system boosts organisational capabilities to ensure the quality of raw materials and final products. Abbas (2020) emphasised that the quality management system, with its continuous improvement approach and customer focus, can improve the production performance of the organisation to meet the needs of its customers and other stakeholders. In contrast, the effect of HRM (E7) on the environmental management system (E3) is rejected (0.505). The existing literature demonstrates that employee knowledge and skills impact the efficient utilisation of resources supporting environmental sustainability (Abbas, 2020). Agi and Nishant (2017) demonstrated that educating employees about the environmental aspects of organizational activities and involving them in the use of incentive programs encourages the development of methods and initiatives aimed at supporting the environment. Turner et al. (2019) demonstrated that an educated human resource facility provides valuable contributions to organizational initiatives such as social responsibilities or environmental management issues. Nevertheless, the hypothesis for this link was rejected in our analysis. It can be concluded that employees in developing countries need to be educated about sustainable environments and learn methods and initiatives to participate in incentive programs to support the environment.

The results of this section indicate that, with the TQM approach, organisations can efficiently manage their tangible and intangible resources to enhance workforce skills, and supply chain capabilities to preserve natural resources while achieving sustainability in the supply chain.

5. Discussion

In recent years, the scope of research about SSCM has been expanded. Different studies have focused on different elements of SSCM. The main contribution of this study is to provide a framework for SSCQM and related practices based on the RBV theory. We extend the previous conceptual framework of SSCQM proposed by Bastas and Liyanage (2018) in our study. They pointed to the fact that incorporation of sustainability into quality and SCM is a highly emerging area with multi-dimensional aspects (financial, ecological and social) aimed at sustainable supply chains. Bastas and Liyanage (2019) reviewed the model's integrating quality, supply chain and sustainability management. Also, Bastas and Liyanage (2019) proposed a model that would incorporate ISO9001 quality management principles across the supply chain for organizational sustainable development.

Our study contributes to theory and practice by analysing the role of TQM in SSCM. From a theoretical perspective, this research contributes to the fields of TQM, RBV and SSCM by exploring how TQM resources and capabilities enable the achievement of sustainability in the supply chain. The chosen components to analyse the role of TQM in SSCM are quality management system, customer focus, environmental management systems, cross-functional cooperation, supply chain capabilities, social issues, and HRM.

First, the outcomes of the grey-based DEMATEL technique demonstrated that supply chain capabilities (E5) and social issues (E6) received the highest priority in the cause group followed by cross-functional cooperation (E4), and quality management system (E1). Moreover, HRM (E7), environmental management systems (E3) and customer focus (E2) are in the effect group and are affected by the cause group.

Different capabilities of the supply chain play important roles in having SSCM. Providing and focusing on different capabilities along the supply chain maintains SSCM. Also, focusing on social issues preserves the cultural, social and economic aspects of the environment in which a supply chain operates. It enhances different capabilities and is an effective influence on different components which help in sustainable growth. HRM is the most impressive component. It shows that developing and training employees can help managers and practitioners achieve a sustainable supply chain.

Second, The CBSEM results showed that 10 hypotheses out of 12 were accepted in the path model developed based on the results of the grey-based DEMATEL technique. The results validated the effect of cross-functional cooperation (E4) on quality management systems (E1), supply chain capability (E5), social issues (E6) and HRM (E7). Moreover, the effect of supply chain capabilities (E5) on customer focus (E2) and environmental management systems (E3) and the effect of social issues (E6) on customer focus (E2) and environmental management system (E3) are supported by the analysis, the exception being the effect of social issues on HRM (E7). Although the effect of social issues on HRM was proved in previous studies (for example (Gorski, 2017; Wan et al., 2021; Sarvaiya et al., 2018)) but it was rejected in the current study. It shows that social issues, especially social responsibility, is a new emerging field of study in a developing country like Iran and is needed to develop human resources in order to enhance responsibility in terms of social issues. Furthermore, the effect of the quality management system (E1) on supply chain capabilities (E5) and HRM (E7) were supported in our study. In contrast, the effect of HRM (E7) on the environmental management system (E3) was rejected, although the existing literature (for example (Abbas, 2020)) supports this link. There are different reasons for such contradictions. First, it shows that developing countries need to teach employees about the sustainable environment. Second, in the current case, human resources are not directly influential on environmental management systems. The current case is comprised of five major manufacturing industries in Iran. Therefore, there may be some contextual variables mediating the current relationships. It is suggested that future research focus on mediation variables. These constructive results revealed that TQM assists in identifying the resources influencing the sustainability of a supply chain. The analysis also revealed that cross-functional cooperation (E4) and supply chain capabilities (E5) are imperative in achieving sustainable objectives. We developed this theory by focusing on the resources and capabilities of the firms working in the industries studied.

From a managerial perspective, this study illustrates the importance of utilising different TQM resources and capabilities to reach sustainability objectives and demonstrates how organisations can achieve sustainability by integrating TQM and RBV perspectives in sustainable supply chains. The analysis emphasised the interrelation and level of importance of the identified resource components while proposing a model and testing it based on empirical data. Causal relationship between the core resources and capabilities, SCM, sustainability, and TQM were identified and structured under a novel framework of SSCQM for sustainable development in industry. SSCQM theory provided a novel viewpoint on sustainability, SCM and TQM for practitioners. The theoretical constructs tried to capture SSCQM and develop the interrelationships of the triple bottom line, SCM, quality and resources and capabilities. Such a model contributes to society, industry and the research stream not only to focus on the resources and sustainable consumption, but also aspects of quality in a sustainable supply chain. Such fruitful theory provides a roadmap for organizational managers, decision makers and practitioners to support sustainability in their organizations by focusing on resource utilization which can not only enhance sustainability, but also quality principles in the organization.

6. Conclusion

Many industries are contributing to environmental pollution. Hence, implementing sustainability practices along the supply chain has received the attention of many practitioners in various industries. Our study investigated the role of TQM in SSCM based on the identified tangible and intangible resources of TQM in an RBV perspective. For this study, we identified seven resource components i.e. quality management system, customer focus, environmental management system, cross-functional cooperation, supply chain capabilities, social issues, and HRM.

The results of the grey based DEMATEL technique indicated that supply chain capabilities, social issues, cross-functional cooperation and quality management system are the most effective TQM factors in SSCM. The results revealed that amongst the seven components, cross-functional cooperation has an effective influence on quality management system, supply chain capabilities, social issues, and HRM; furthermore, supply chain capabilities are effective factors on customer focus and environmental management system. Also, it was found that social issues have an effective influence on customer focus, environmental management system and HRM while quality management system is an effective factor on supply chain capabilities and HRM. However, the results showed that the effect of HRM on environmental management system was not significant in contrast to the findings of previous literature.

This study highlighted several future research perspectives. There are some context variables which mediate the relationships between the components such as the degree of economic development, organizational size, and type of industry which should be considered in future research. Also, it is suggested that researchers try to provide different inter-relationship models in various industries and not only demonstrate the importance of the different variables in them, but also examine the dynamic interrelationships among the variables. Furthermore, it is suggested that more variables should be considered to achieve a wider perspective for the model.

Our study had certain limitations. Firstly, the collected data were confined to the perceptions of the manufacturing industry practitioners and managers who participated in the survey. Although the findings were based on a relatively a large dataset, generalization of the results should be done cautiously. The dataset of this study was limited to five manufacturing industries in a developing country, Iran. The results can be generalized for the manufacturing industries of other developing countries and the results can be compared with those of our study; but this limits the generalizability of the findings with respect to different industries, regions etc. Therefore, future research can be conducted in order to expand the analysis to developed countries.

Declaration of Competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.spc.2021.07.013.

Appendix A

DEMATEL steps:

The first step contains sub-steps 1a-1d

Step 1a: A grey pairwise of the components should be defined in order to compare the influences of the components.

Step 1b: The grey direct-relation matrix X should be developed which is based on expert opinion and introduces the grey pairwise inter-influence ($\otimes x_{ij}^{k}$) of the factors in an $n \times n$ matrix. All the principal diagonal elements are initially set to a crisp value of zero ("N" = no influence), then the grey numbers, which are 0–0.2 (very low influence), 0.2–0.4(low influence), 0.4–0.6(moderate influence), 0.6–0.8(high influence), 0.8–1(very high influence) are used to demonstrate expert opinions. The value of $\otimes x_{ij}^{p}$ is the grey number for an evaluator (decision maker) p, who measures the effect of factor i on factor j. Also, $\underline{\otimes} x_{ij}^{p}$ and $\bar{\otimes} x_{ij}^{p}$ are respectively, the lower and upper grey values for evaluating the effects of factor i on factor j which is dedicated by an evaluator, that is $\otimes x_{ij}^{p} = [\underline{\otimes} x_{ij}^{p}, \bar{\otimes} x_{ij}^{p}]$

Step 1c: The grey direct-relation matrices should be converted into a crisp matrix Z.

This should be based on the modified-factors process as exemplified by Eq. (1)- (3).

The following three-step procedure is a modified-factor method:

$\underline{\otimes}\widetilde{x_{ij}^{p}} = [\underline{\otimes} x_{ij}^{p} - \min \underline{\otimes} x_{ij}^{p}] / \Delta_{min}^{max}$, (1)

j

$\bar{\otimes}\widetilde{x_{ij}^{p}} = [\bar{\otimes} x_{ij}^{p} - \min \bar{\otimes} x_{ij}^{p}] / \Delta_{min}^{max}$, (2)

j

where $\Delta_{min}^{max} = \max \bar{\otimes} x_{ij}^{p} - \min \underline{\otimes} x_{ij}^{p}$, (3)

j

(2) The total normalized crisp value should be determined as follows,

$y_{ij}^{p} = \left(\underline{\otimes}\, \widetilde{x_{ij}^{p}}\ (1 - \underline{\otimes}\, \widetilde{x_{ij}^{p}}) + (\bar{\otimes}\widetilde{x_{ij}^{p}} \times \bar{\otimes}\widetilde{x_{ij}^{p}}\right) / \left(1 - \underline{\otimes}\, \widetilde{x_{ij}^{p}} + \bar{\otimes}\widetilde{x_{ij}^{p}}\right)$ (4)

(3) and the final crisp values will be computed

$z_{ij}^{p} = min \underline{\otimes} x_{ij}^{p} + y_{ij}^{p} \Delta_{min}^{max}$ (5)

j

If more than one respondents complete the matrices, there will be a return to step 1d, otherwise a move to step 2.

Step 1d: Evaluator weightings should be done for each respondent for aggregation purposes. To do so, either simple averaging (Eq. (6)) or weighted averaging (Eq. (7)) can be utilized. Eq. (7) will be applied, which is required to specify the evaluator weightings, and is defined by grey linguistic scale values for each respondent p ($\otimes w_p$). Grey scaled evaluation weightings will be crisped and the sum should be 1 as shown in Eq. (7).

$z_{ij} = {}^{1}/_{p}\ (z_{ij}^{1} + z_{ij}^{2} + \ldots + z_{ij}^{p})$. (6)

$z_{ij} = w_1 z_{ij}^{1} + w_2 z_{ij}^{2} + \ldots + w_p z_{ij}^{p}$ *such that* $\sum_{i=1}^{p} w_i = 1$. (7)

Where z_{ij} is the overall crisp evaluation for the relationships between factors i and j, z_{ij}^{p} is the crisp value of evaluating the relationship between factors i and j which is done by respondent p; w_p is the crisp value of the evaluator weight which is assigned to evaluator p derived from the grey scale weight for each evaluator ($\otimes w_p$).

Step 2: After evaluating the overall crisp direct-relation matrix Z, the normalized direct-relation matrix N will be obtained through Eq. (8) and Eq. (9):

$N = s \times N$ (8)

$s = {}^{1}/\max_{1 \le i \le n} \sum_{j=1}^{n} z_{ij} i.\ j = 1.2 \ldots .n$ (9)

Step 3: The total relation matrices (T) will be determined by Eq. (10) where I represents $n \times n$ an identity matrix,

$T = N + N^2 + N^3 + \ldots = \sum_{i=1}^{\infty} N^i = N(I - N)^{-1}$ (10)

Step 4: The causal influence and digraph diagram in DEMATEL can be developed through the following three sub-steps:

Step 4a: row (R_i) and column (D_i) sums for each row i and column j from the total relation matrices (T) should be determined, that is:

$R_i = \sum_{j=1}^{n} t_{ij}\ \forall i.$ (11)

$D_j = \sum_{i=1}^{n} t_{ij}\ \forall j.$ (12)

R_i, the row values, are the total effect (direct and indirect) of a factor i on the model. And also, D_j, the column values, demonstrate the overall direct and indirect effects of all factors on factor j.

Step 4b: The overall importance or prominence (P_i) of a factor i and net effect (E_i) of factor i will be determined using Eq. (13) and Eq. (14).

$p_i = \{D_i + R_j | i = j\}$ (13)

$E_i = \{D_i - R_j | i = j\}$ (14)

The larger the value of *Pi*, the greater the overall influence of factor i in terms of overall relationships with other factors. If $E_i > 0$ then the factor is a net effect and if $E_i < 0$, then factor i is the cause of other factors. These values may then be plotted onto a two dimensional axis for each SSCM factor.

Step 4c: A digraph relationship can be determined for an SSCM model.

Appendix B

Quality management system-determines how the organization develops its strategies, objectives and policies, in order to improve sustainability along the supply chain by focusing on product quality, resource consumption and worker awareness as regards objectives.		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
QM1	Improving product quality					
QM2	Worker awareness of quality policies					
QM3	Long term objectives for quality improvement					
QM4	Consuming the least amount of resources, such as water, electricity and gas					
Customer focus- refers to improving the quality of existing products and services which fulfil the demands of customers and other stakeholders while reducing waste.						
CF1	Understanding the current and future needs of customers					
CF2	Linking the objectives of the organisation to customers					
CF3	Sustainable consumption (Green consumer attitude)					
Environmental management system- focuses on preventing pollution, managing sustainable resource consumption and mitigating climate changes for an eco-friendly environment						
ES1	Improving energy efficiency					
ES2	Prevention of pollution					
ES3	Protection of the environment and restoration of natural habitats					
Cross-functional cooperation- refers to how the organization plans and manages its external collaborators and internal resources to gather data in order to support sustainability along the supply chain.						
CC1	Information exchange and teamwork					
CC2	Cross-functional cooperation between different areas					
CC3	Supplier management					
Supply chain capabilities- refers to the intangible resources of organizations which are obtained via integration, collaboration and coordination techniques in order to improve supply chain visibility and efficiency by sharing information, integrating the upstream and downstream supply chains and synchronising transactional activities along the supply chain.						
SC1	Information sharing capabilities					
SC2	Coordination capabilities					
SC3	Integration capabilities					
Social issues- refers to ethical and social practices which increase organisational competitive advantage while reaching sustainable development goals						
SI1	Fair competition					
SI2	Promoting social responsibility in the value chain					
SI3	Respect for property rights, ethics and social equity					
HRM-determines how the organization manages and develops the knowledge of the people comprising it, and releases all their potential, both individually and in the team, and in the whole organization, and how it plans to protect employees in terms of safety and social issues as well as providing financial support for them in order to motivate them to work in alliance with organizational polices and strategies, and, consequently, have effective performance.						
HR1	Employment relationships					
HR2	Health and safety and social protection at work					
HR3	Human development and training in the workplace					
HR4	Providing financial support to workers (e.g. payable salary)					

Appendix C

Notes

E1: Quality management system**, E2:** Customer focus, **E3:** Environmental management system, **E4:** Cross-functional cooperation, **E5:** Supply chain capabilities, **E6:** Social issue, **E7:** HRM**.**

Table C.1
The weighted aggregate data.

factors	E1	E2	E3	E4	E5	E6	E7
E1	0,0	0,0.2	0,0.2	0.25,0.67	0.6,1	0,0.2	0.6,1
E2	0.15,0.4	0,0	0.45,0.8	0.25,0.67	0.15,0.4	0.15,0.4	0.15,0.4
E3	0.3,0.6	0.15,04	0,0	0.25,0.67	0.3,0.6	0.3,0.6	0.15,0.4
E4	0.6,1	0,0.2	0,0.2	0,0	0.3,0.6	0.6,1	0.15,0.4
E5	0.15,0.4	0.6,1	0.6,1	0.25,0.67	0,0	0.3,0.6	0,0.2
E6	0.15,0.4	0.6,1	0.15,0.4	0.25,0.67	0,0.2	0,0	0.6,1
E7	0.15,0.4	0.3,0.6	0.45,0.48	0.5,1	0.15,0.4	0.15,0.4	0,0

Table C.2
The normalized aggregate data.

factors	E1	E2	E3	E4	E5	E6	E7
E1	0,0	0,0.16	0,0.16	0.12,0.32	0.48,0.8	0,0.16	0.48,0.8
E2	0.12,0.32	0,0	0.36,0.64	0.12,0.32	0.12,0.32	0.12,0.32	0.12,0.32
E3	0.24,0.48	0.12,0.32	0,0	0.12,0.32	0.24,0.48	0.24,0.48	0.12,0.32
E4	0.48,0.8	0,0.16	0,0.16	0,0	0.24,0.48	0.48,0.8	0.12,0.32
E5	0.12,0.32	0.48,0.8	0.48,0.8	0.12,0.32	0,0	0.24,0.48	0,0.16
E6	0.12,0.32	0.48,0.8	0.12,0.32	0.12,0.32	0,0.16	0,0	0.48,0.8
E7	0.12,0.32	0.24,0.48	0.36,0.64	0.24,0.48	0.12,0.32	0.12,0.32	0,0

Table C.3
The grey direct-relation matrices.

	E1	E2	E3	E4	E5	E6	E7
E1	0.56	0.70	0.73	0.59	**0.86**	0.60	**0.88**
E2	0.55	0.53	0.75	0.50	0.57	0.56	0.60
E3	0.67	0.70	0.62	0.55	0.69	0.67	0.68
E4	**0.91**	0.79	0.77	0.57	**0.82**	**0.91**	**0.86**
E5	0.73	**1.02**	**1.05**	0.65	0.67	0.80	0.74
E6	0.68	**0.96**	**0.81**	0.63	0.63	0.60	**0.95**
E7	0.66	0.78	**0.87**	0.65	0.67	0.67	0.63

Table C.4
The degree of prominence and net cause/effect of factors.

factor	E1	E2	E3	E4	E5	E6	E7
Pi= $\boldsymbol{D_i} + \boldsymbol{R_j}$	9.7	9.5	10.2	9.8	10.5	10.1	10.3
Ei= $\boldsymbol{D_i} - \boldsymbol{R_j}$	0.1	−1.4	−1.0	1.5	0.8	0.4	−0.4

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