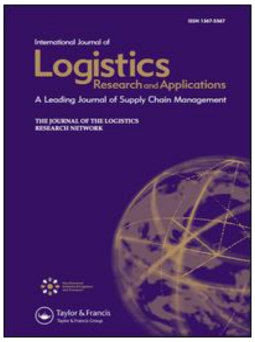

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Investigating barriers to circular supply chain in the textile industry from Stakeholders' perspective

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ABSTRACT
The objectives of this study are to understand the circular supply chain barriers for textile companies to implement the circular economy. Main contributions of the study were to propose a specific framework that reveals circular supply chain barriers in transition to circular economy with holistic view by encompassing all stakeholders, to reveal causal relationships among the circular supply chain barriers within textile industry. Causal relationships between the proposed circular supply chain barriers were identified by Fuzzy-Decision Making Trial and Evaluation Laboratory (DEMATEL) method. The barriers are classified under cause and effect groups and related implications are proposed. The findings of this study are lack of collecting, sorting and recycling, reluctance for acceptance of CE model, and problems related to uniformity and standardisation are revealed as the most important barriers, respectively. Moreover, lack of technical knowledge is the most influencing factor, whereas, challenges in product design is the most influenced factor.

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Circular economy; DEMATEL; circular supply chain barrier; textile industry; Stakeholders' perspective

1. Introduction

The circular economy (CE) has been becoming more important for manufacturing companies in today's world since the increasing importance of the sustainability and the environmentally friendly activities. The transition from linear economy to the CE is inevitable for manufacturing companies to have sustainable and fair global economy (Vermeulen 2015). Sustainable development concerns such as climate change and increasing carbon emissions have forced companies to change their way of doing business from linear economy to the CE (Mazzanti and Montini 2014; Atlason, Giacalone, and Parajuly 2017; Coste-Maniere et al. 2019; Zhou, Song, and Cui 2020).

The CE and its implementations have been mostly used in the textile industry, which was the largest manufacturing industry that pollutes the environment because of its complex process. The textile industry is the second most polluting sector in the world (Malik et al. 2014), because it has a SC where toxic substances polluting air, water, and soil are used extensively. The amounts of textile waste have been increasing globally, however, recycling or reusing of textile products would reduce the new wastes from virgin materials (Dahlbo et al. 2017). In addition, textile industry also uses excessive water to complete the manufacturing process and all manufacturing processes in textile industry are very water-intensive (Ellen MacArthur Foundation 2017; Rathinamoorthy

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2019). Therefore, the use of CE principles plays an important role in reducing pollution in textile industry via material and energy density, reducing materials, reusable materials, using less toxic materials, increasing recycling ability, focusing on resource efficiency, using products for a long time, producing value-added products, and eliminating waste (Snoek 2017; Koszewska 2018; Kumar and Carolin 2019; Pathak and Endayilalu 2019). In this way, final product and fibre demand is greatly reduced (Koszewska 2018).

Textile companies launch new items with short product life cycle, and this leads to less durable quality and more costs (Mukherjee 2015). The consumption of textile items and the waste of textile products have been rising dramatically. The waste taken from the manufacturing process would be a significant input for another manufacturing process that encompasses raw material, harvesting, designing, yarn manufacturing, spinning, weaving, dyeing, stitching, and cutting (Smith, Baille, and McHattie 2017). It is obvious that today's linear economy cannot accomplish a sustainable manufacturing process; therefore, the CE is a need for especially textile industry (Mukherjee 2015; Ræbild and Bang 2017; Koszewska 2018). However, it was suggested to the textile companies to transform their capabilities from linear economy to the CE, there have been many barriers that companies encounter during this process. Therefore, this study focused on the barriers that prevent companies adapting the CE implementations.

Each step in the manufacturing of final products is affected by another step in a textile company's supply chain (SC), which has several stakeholders such as designers, material converters, garment manufacturers, brand owners, and retailers (Cao et al. 2008; Snoek 2017; Kirchherr et al. 2018). Adapting the CE implementations requires the whole SC entities adapt them (Bianchini, Rossi, and Pellegrini 2019). In the circular supply chain (CSC) of a textile company, the processes in the chain such as collecting, separating, classifying, and recovering should be improved concurrently and should be operated with minimum harmful environmental impacts (Dahlbo et al. 2017). In the CE, the whole SC and its processes should be adapted to sustainability based on optimum utilisation of all resources (Coste-Maniere et al. 2019). Because of these reasons, this study analysed the SC barriers in the transition to the CE in textile industry. Masi et al. (2018) stated the need for analysing the specific industries in different geographical contexts. It is important to understand the CE concept in developing countries. Thus, a number of studies have examined and suggested possible frameworks for implementation of the CE for various sectors in emerging economies (Mangla et al. 2018; Farooque et al. 2019; Batista et al. 2019; Deineko, Tsyplitska, and Deineko 2019; Jugend et al. 2020; Khandelwal and Barua 2020; Jabbour et al. 2020). Also, there are few studies conducted in the context of the textile industry (Moktadir et al., 2020; Snoek 2017; Daňo, Drábik, and Hanuláková 2020). The study was conducted in Turkey, which is a textile country and a developing country. The SC stakeholders of the textile companies in Turkey have been improving dramatically. Due to the increasing importance of Turkey in the global textile industry over the world, the field study was implemented to the Turkish textile companies' SC stakeholders.

The main aim of the study was to reveal the CSC barriers for textile companies to implement the CE. The main contributions of the study were (i) to propose a specific framework that reveals CSC barriers in transition to CE with a holistic view by encompassing all the stakeholders, and (ii) to reveal the causal relationships among the CSC barriers within textile industry. Therefore, research questions were developed as follow:

RQ1: Revealing the CSC barriers within the complex structure of textile industry?

RQ2: What are the causal relationships among these CSC barriers within textile industry?

In the study, initially, the relationship between SC and CE was investigated and the importance of CSC was mentioned, then the CSC barriers that prevent companies implementing CE in textile industry were examined. The causal relationships among the barriers were investigated using Fuzzy-DEMATEL method. In the implementation part, the interviews with the textile companies conducted and the DEMATEL method was implemented. Lastly, the results of the study were discussed, and both managerial as well as policy implications were proposed based on the results of DEMATEL method to overcome barriers in textile industry context.

The paper is structured as follows; Section 2 provides a brief literature review, in Section 3 CSC barriers to implement CE in the Textile industry is presented, Section 4 exhibits methodology used in the paper, a case study in textile industry is given in Section 5, results in Section 6, discussion and implication in Section 7–8, and finally, the paper is concluded in Section 9.

2. Literature review

CE is a closed-looped industrial economic model that aims to minimise waste while keeping materials, product value, and resources within the economy as much as possible via restoration and reuse, renewable energy, elimination of toxic chemicals usage, sustainable design (Spring and Araujo 2017; Cheng and Chou 2018; Daae, Chamberlin, and Boks 2019; Kumar and Carolin 2019). The principles of the CE, initially was laid with 3R – Reduce, Reuse, and Recovery – include 10Rs – Reduce, Repair, Renew, Reuse, Remanufacture, Recycle, Refurbish, Repurpose, Recover, and Refuse (Ellen MacArthur 2013; Cramer 2017).

With the transition of textile industry from linear economy to the CE, by changing the way of design, manufacturing, marketing, transportation, and consumption of products within the textile value chain and reducing the use of resources, companies provide the sustainable business model (Malik et al. 2014; Song and Wang 2017). The CE requires the participation of all stakeholders in the market, and collaboration is shaped by repair, reuse, renewal, and reproduction and recycling throughout the life cycle of all production, consumption, and resources (Boiten, Li-Chou Han, and Tyler 2017; Jakhar et al. 2018). Sustainable production and consumption require collaborative association among supply chains and operational efficiencies which means active engagement, cooperation, mutual understanding, collaboration, and feedback between various stakeholders in the market. Briefly, the CE cannot be fully implemented successfully without managing the relationships between various stakeholders by considering their roles in the process that are shaped by reduce, repair, reuse, renewal, reproduction, refurbishing, and recycling throughout the value chain (Boiten, Li-Chou Han, and Tyler 2017; Jakhar et al. 2018; Gupta et al. 2019; Camilleri 2020; Jabbour et al. 2020; Rossi et al. 2020). Lifecycle of a product in the CE is longer than in the linear economy because in a CE approach products are designed to be modular, durable, value-added, and also recyclable by recovering material, energy, and water (Fischer and Pascucci 2017; Schroeder, Anggraeni, and Weber 2018; Manickam and Duraisamy 2019). Thus, a systematic material flow and a coordinated SC are crucial to circulate the loops continuously (Govindan and Hasanagic 2018; Kumar et al. 2019). As the CE has an interdisciplinary structure, the implementation of CE necessities a collaboration of the related sectors of the manufacturing industry such as designers, raw material suppliers, and other services providers (Fischer and Pascucci 2017; Rathinamoorthy 2019). SC coordination encompasses all kinds of cooperation and collaboration efforts within direct/indirect parties involved in the value chain such as manufacturers, designers, raw material suppliers and other collectors, government, retail stores, end-users (Cao et al. 2008; Fischer and Pascucci 2017; Gupta et al. 2019; Pandit, Nadathur, and Jose 2019; Rathinamoorthy 2019). The textile industry is a good example to present the limits of the current linear economy model (Koszewska 2018).

The textile industry has a long SC, including design, sourcing, fibre and clothing manufacturing, packaging and delivery, waste management, use and restoration (Clancy, Fröling, and Peters 2015; EURATEX 2017; Jia et al. 2020). Most companies in the textile industry operate in the linear economy (Franco 2017). In the CE, textile wastes are used as a resource with reverse logistics applications and are based on extending the life cycles of textile products and effective use of resources (Bouzon, et al. 2016). Thus, CSC is a complex system based on effective waste management, recycling, remanufacturing, and reusing materials and waste (Mangla et al. 2018; Koszewska

2018). The CSC is difficult to manage because it has a very long SC and materials are supplied from many large and small companies from countries with lower labour costs – e.g. companies in Asia (Snoek 2017).

The SC in textiles consists of different industries and collaborations, the transition to the CE, the minimisation and recycling of waste at all levels is the common responsibility of all companies (Pathak and Endayilalu 2019). In this process, environmentally conscious suppliers, manufacturers, retailers, and users need to be integrated into the entire SC. Besides, some companies may not be willing to adopt the CE (Rathinamoorthy 2019). However, for a full circular business model in textile industry, the whole SC must act in accordance with CE principles (Kirchherr et al. 2018; Koszewska 2018). Thus, the entire infrastructure and SC need to be changed (Snoek 2017; Ellen MacArthur Foundation 2017). In addition to the SC actors, other stakeholders have a vital impact on the CE activities in textile industry (Pathak and Endayilalu 2019; Sandvik and Stubbs 2019). Therefore, the literature examining the implementation of sustainability across major SC highlights the need for a systematic and holistic approach to the CE when all relevant stakeholders are redesigned (Ræbild and Bang 2017; Bressanelli, Perona, and Saccani 2019). Stakeholders in the textile CSC include fibre production, yarn manufacturers, fabric manufacturers, garment manufacturers, designers, retailers, end-users, collectors, and recycling companies (Cao et al. 2008; Dahlbo et al. 2017; Pandit, Nadathur, and Jose 2019). The stakeholders in textile CSC are based on the classification of European Commission (2017); Design4Circle (2019); Wicher et al. (2018); EUROTEX (2019); Boiten, Li-Chou Han, and Tyler (2017); Snoek (2017); Fontell & Heikkilä (2017); ECAP (2019). In the beginning of the textile CSC, collectors and recyclers play a critical role in collecting used or unused textile wastes for reuse or recycling from textile industry, classifying them according to their colours and type of materials, and removing accessories such as staples and zippers on the materials (ECAP 2019). In colour separation, it means that repainting is not necessary in terms of energy-saving and prevention of pollutants (Sandvik and Stubbs 2019). Textile waste is turned into recycled fibre by fibre manufacturers (Fontell & Heikkilä 2017). Later, recycled fibre is used as the raw material and turned into the yarn. Yarn producers combine with other fibres related to the final use of the yarn. This process is provided to reduce energy savings, use less raw materials, and decrease environmental impact (Design4Circle 2019; Snoek 2017). Fabric manufacturers conduct recycling by converting waste to recycled yarns and clothing (ECAP 2019; Charter 2018). The role of designers in this process is to design the products in a way that will minimise waste in production, reuse the textile waste within the design of clothing with minimal loss of quality, and encourage the use of recyclable local materials (Wilson 2015; Ozdamar Ertekin and Atik 2020). Garment manufacturers use textile fibre fabrics that are recycled after the consumption of the end-users or discarded textile accumulated among the chain. They can also use recycled industrial textile waste and PET bottles in production (EUROTEX 2019). In the textile CSC, retailers and fashion brands play an active role in promoting the SC to move to the CE, creating awareness and increasing transparency in the chain (ECAP 2019). Moreover, end-users need to discard all kinds of clothing and home textile products that they no longer need for reasons such as aging, undercoating, or losing fashion features and decide to throw in the recycling bins of municipalities or large retail stores (Buyukaslan, Jevsnik, and Kalaoglu 2015). The role of end-user should not be ignored because the involvement of user in supply chain decisions offers innovative ideas, affects product cost, and optimum price. Firms can provide this participation with cloud computing platforms (Chen, Duan, and Zhang 2020). Besides, sellers can give information and promote their products to customers (Wu and Tsai 2018). The government and policymakers have a significant role and influence in the implementation of the CE (Govindan and Hasanagic 2018; Song et al. 2020; Zhou, Song, and Cui 2020). Therefore, the government and policymakers directly or indirectly affect the stakeholders' behaviour in line with the CE.

Figure 1 exhibits the stakeholders in the CSC, from raw material to design and till the products reach the end-users and then collected and recycled in textile industry within a closed-loop

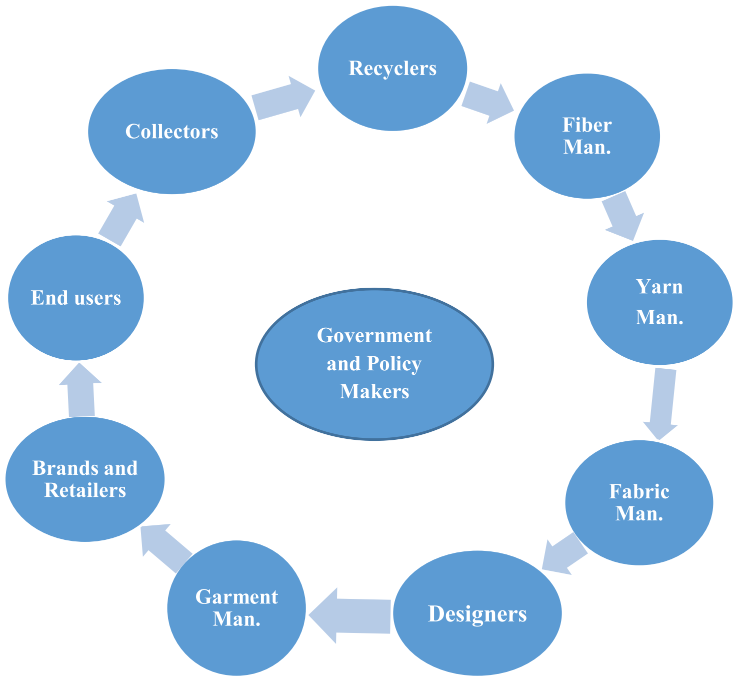

Figure 1. CSC Stakeholders in textile industry.

structure. In the complex structure of the CSC in textile industry, each stakeholder acts as an independent actor that needs to implement collaboration, communication, and coordination in the network structure (Fontell & Heikkilä, 2017).

In order to implement the CE in textile SC the barriers embracing the whole chain should be investigated. Implementation of the CE refers to the need for a multidimensional array of indicators rather than a single one (Rossi et al. 2020). These barriers should be highlighted within the systems approach to cover all members and stages of the SC within the transition to CE. In literature, especially Rizos et al. (2016); Franco (2017); Tura et al. (2019) have investigated the barriers associated with the SC and its members. However, to the best of our knowledge there is no study highlighting barriers to CSC within textile industry. Therefore, in the next section the CSC barriers to implement CE in textile sector will be scrutinised.

3. CSC barriers to implement CE in the textile industry

The literature for analysing the barriers was investigated using keywords such as 'CE barriers/obstacles', 'CSC barriers in textile/apparel industry', 'green SC barriers', and 'sustainable SC barriers', 'challenges in textile industry'. Google Scholar, Web of Science, ScienceDirect, Scopus, Emerald databases were used to search the related articles. While determining this barrier list, it was applicable to textile industry. The barrier list was identified with 25 barriers through literature review. As CE is a structured approach, it requires effective SC management and integration among the stakeholders in the product lifecycle (Atlason, Giacalone, and Parajuly 2017; Tseng et al. 2020). However, there are SC barriers that hinders a robust CE implementation should be identified (Mont et al. 2017; Pheifer 2017; Jakhar et al. 2018; Kirchherr et al. 2018). In this study, the CSC barriers were also classified according to the relationship of one or more stakeholders involved. In this way, the barrier that different stakeholders may encounter in the implementation of the CE in the SC of a textile company is shown in Table 1.

Table 1. Framework for CSC barriers and stakeholders in textile industry.

Main categories	Barrier name	Fibre Man.	Type of stakeholders Yarn Man.	Fabric Man.	Garment Man.	Designers	Brands & retailers	End users	Collectors	Recyclers	Government & policy makers
MANAGERIAL **ISSUES**	C1 Performance assessment problem	**X**	**X**	**X**	**X**				**X**	**X**	
	C2 Reluctance for acceptance of CE	**X**	**X**	**X**	**X**	**X**	**X**				**X**
	C3 Problems of tracking & tracing	**X**	**X**	**X**	**X**		**X**		**X**	**X**	
HUMAN **RESOURCES**	C4 Labour intensiveness	**X**	**X**	**X**	**X**				**X**	**X**	
	C5 Need for skilled labour	**X**	**X**	**X**		**X**				**X**	
DESIGN ISSUES	C6 Need for complementary processes				**X**	**X**					
	C7 Challenges in product design				**X**	**X**	**X**	–		**X**	
RAW MATERIALS	C8 Procurement problems for recyclable materials	**X**	**X**	**X**	**X**			**X**	**X**	**X**	
	C9 Quality problems	**X**	**X**	**X**	**X**					**X**	
	C10 Challenges in material structure	**X**	**X**	**X**	**X**	**X**			**X**	**X**	
	C11 High raw material costs	**X**	**X**	**X**	**X**		**X**	**X**			
POLICY RELATED CHALLENGES	C12 Problems related to uniformity & standardisation	**X**	**X**	**X**	**X**						**X**
	C13 Certification problems	**X**	**X**	**X**	**X**				**X**	**X**	**X**
INFORMATION & AWARENESS	C14 Lack of awareness	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**	**X**
	C15 Lack of theoretical knowledge	**X**	**X**	**X**	**X**	**X**			**X**	**X**	
	C16 Lack of technical knowledge	**X**	**X**	**X**	**X**	**X**			**X**	**X**	
COOPERATION & COLLABORATION	C17 Communication & coordination problems	**X**	**X**	**X**	**X**		**X**		**X**	**X**	
	C18 Supplier inconsistency	**X**	**X**	**X**	**X**		**X**		**X**	**X**	
	C19 Lack of vision & trust	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**	**X**
ECONOMIC	C20 High initial costs	**X**	**X**	**X**	**X**				**X**	**X**	
	C21 Vagueness in profit margins & rate of return	**X**	**X**	**X**	**X**		**X**		**X**	**X**	
	C22 Diseconomies of scale	**X**	**X**	**X**	**X**		**X**		**X**	**X**	
INFRASTRUCTURAL & TECHNOLOGICAL	C23 Lack of high-tech in reverse logistics								**X**	**X**	
	C24 Lack of infrastructure								**X**	**X**	
	C25 Lack of collecting, sorting & recycling								**X**	**X**	

Managerial issues: Managerial issues are about business level activities which include 'performance assessment problem (C1)', 'reluctance for acceptance of CE (C2)', 'problems of tracking and tracing (C3)'. If there are lacks of a quantitative performance measuring system and performance indicators regarding CE, it causes managerial problems, especially on the behalf of yarn, fabric and garment manufacturers, collectors, and recyclers (Su et al. 2013; Mangla, Govindan, and Luthra 2017; Govindan and Hasanagic 2018; Bianchini, Rossi, and Pellegrini 2019; Jia et al. 2020). Beyond performance assessment problems, companies may hesitate to accept the CE as a business model and this affects yarn, fabric and garment manufacturers, designers, brand owners and retailers, and governments/policymakers (Cao et al. 2008; Govindan and Hasanagic 2018; Kirchherr et al. 2018). This happens when there are negative reactions to change, short-term focus and applying the CE is found risky (Kumar et al. 2019; Kumar and Suganya 2019). Problems of tracking and tracing refer difficulty of monitoring the product's life cycle and material flows in the CE experienced by yarn, fabric and garment manufacturers, brand owners and retailers, collectors and recyclers (Elia, Grazia Gnoni, and Tornese 2017; Govindan and Hasanagic 2018; Kumar and Suganya 2019). This difficulty also occurs because of the lack of data (e.g. about material location, the determination of components and materials and their related typology, status, and quantity) and suitable information for decision-making processes (Tatoglu et al. 2016; Kirchherr et al. 2018; Baltussen 2019; Bianchini, Rossi, and Pellegrini 2019). For continuous traceability, not only the materials and products but also the waste should be monitored (Bianchini, Rossi, and Pellegrini 2019).

Human resources: Human resources category is about 'labour intensiveness (C4)' and 'need for skilled labour (C5)'. There is a labor-intensive structure in the circular textile industry and it negatively affects yarn, fabric and garment manufacturers, designers, and recyclers (Mont et al., 2017). Especially, collecting and separating disposed of textiles for reparation to recycling are labour-intensive activities (Dodick and Kauffman 2017). Besides, some activities such as bio-refining require skilled labour. However, there is lack of qualified personnel on the CE (Li and Yu 2011; Su et al. 2013) and it puts pressure on yarn and fabric manufacturers, collectors, and recyclers (Morone and Navia 2016; Esposito, Tse, Soufani 2018).

Design issues: Making recyclable and environmentally friendly designs are important to conduct business activities circularly for a textile company (Atlason, Giacalone, and Parajuly 2017). Considering the CE, proper design of the product allows an easier separation of materials, and also contributes to identify the mixture of various materials and components within the textile products (Rathinamoorthy 2019). However, there are challenges affecting the design process such as 'need for complementary processes (C6)', and 'challenges in product design (C7)'. In order to produce apparel, many complementary processes -such as cleaning, coating, dyeing, welding- are needed and garment manufacturers and designers experience these challenges (Koszewska 2018; Jia et al. 2020). In the manufacturing process, avoidance of using toxic materials is another important challenge (Rathinamoorthy 2019). Textile products have complex material composition and it causes difficulties in the disassembly, separation, recycling processes that are the activities affect designers, brand owners, and retailers, end-users (Sabaghi, Mascle, and Baptiste 2016; Franco 2017; ECAP 2019). For example, even if it is successful in producing end products, it is not guaranteed that consumers will like and buy it (Atlason, Giacalone, and Parajuly 2017).

Raw materials: Issues about raw materials are important challenges in the circular textile industry. 'Procurement problems for recyclable materials (C8)', 'quality problems (C9)', 'challenges in material structure (C10)' and 'high raw material costs (C11)' prevent a successful CE application in textile industry. In order to implement a sustainable design strategy, waste should be recycled (Ballie and Woods 2018). However, there is limited quality and availability of recycled materials or it is difficult to recycle (Franco 2017; Kirchherr et al. 2018; Filho et al. 2019). For example, blended polyester and cotton are difficult to recycle (Baltussen 2019). These barriers affect yarn, fabric and garment manufacturers, end-users, collectors, and recyclers (van der Velden, Patel, and Vogtländer 2014). Recycled materials may be in low quality and durability. It causes problems with the quality and expected lifetime of the finished product and makes their activities harder

(Niinimäki and Hassi 2011; Filho et al. 2019). Textile products are complex as they are made of various materials (Parajuly 2017). This complexity makes it hard to decompose textile wastes and reduces the ability to extract secondary raw materials and find alternatives. This situation complicates the work of yarn, fabric and garment manufacturers, collectors, and recyclers (Bastein et al. 2013; Snoek 2017). Another vital barrier in the CE implementation is high raw material costs. Many virgin materials are cheaper than recycled materials because transactions for recycling and collection are expensive (Kumar and Suganya 2019). Therefore, the price of the recycled end products increases, and end-users may not want to buy them. Therefore, manufacturers may not want to produce, and brand owners/retailers may not want to sell recycled products (Fletcher, 2014; Niinimäki and Hassi 2011; Govindan and Hasanagic 2018).

Policy related challenges: Government support and policies are vital for a successful and clear implementation of the CE because they shape companies' future steps (Kumar et al. 2019). Policy related challenges can be discussed under two headings which are 'problems related to uniformity and standardisation (C12)', 'certification problems (C13)'. Policies and laws about the CE are not strong and standardised, and some of them do not fit the CE concept so they restrain the activities of yarn, fabric and garment manufacturers, government and policymakers (Li and Yu 2009; Genovese et al. 2017; de Man and Friege 2016; Maitre-Ekern and Dalhammar 2016). Different standards, lack of standardisation and certification cause confusion about performance assessment, quality, data collection, which negatively affect yarn, fabric and garment manufacturers, collectors, recyclers, and governments/policymakers (Su et al. 2013; Dodick and Kauffman 2017; Hazen, Mollenkopf, and Wang 2017; Baltussen 2019; Luthra, Mangla, and Yadav 2019; Yadav et al. 2020).

Information and awareness: As robust implementation of the CE is dependent on information and awareness, 'lack of awareness (C14)', 'lack of theoretical knowledge (C15)', 'lack of technical knowledge (C16)' hinders successful CE activities. Many companies do not have information about CE and its principles; also, they are not aware of its potential benefits. Hence, yarn, fabric and garment manufacturers, designers, brand owners and retailers, collectors, recyclers, and governments/policymakers are negatively affected by the lack of information, knowledge, and awareness (Geng et al. 2012; Wastling, Charnley, and Moreno 2018; Rathinamoorthy 2019; Yadav et al. 2020). Moreover, if companies do not have expertise in current technologies and practical implementation (e.g. methods of treatment and recovery for discarded textile products), the effectiveness of the process and quality of recycled products may diminish (Dahlbo et al. 2017; Kirchherr et al. 2018; Baltussen 2019; Kumar and Suganya 2019) and this situation negatively affects yarn, fabric, and garment manufacturers, designers, collectors, and recyclers (Ilić and Nikolić 2016).

Cooperation and collaboration: SC of textile industry is long and complex because it encompasses several manufacturing and distribution processes (Cao et al. 2008). Thus, 'communication and coordination problems (C17)', 'supplier inconsistency (C18)', 'lack of vision & trust (C19)' between multiple stakeholders causes problems. Having difficulties about collaboration, information sharing, and getting feedback with SC actors reduces the effectiveness of the CE implementation as it diminishes synchronisation, communication, and monitoring (Dodick and Kauffman 2017; Mont et al. 2017; Mangla, Govindan, and Luthra 2017; Baltussen 2019; Kumar et al. 2019; Patel and Desai (2019); Yadav et al. 2020). Since most of the manufacturers in the textile industry operate in a linear economy, it is difficult to communicate and coordinate with brands and retailers with these manufacturers, collectors, and recyclers in the transition to a CE (Rizos et al. 2016; Mangla et al. 2018; Tura et al. 2019; Kumar and Suganya 2019; Kumar et al. 2019; Luthra, Mangla, and Yadav 2019).

Due to the length of the SC in textiles, the fact that too many suppliers are included in the process from the harvest to the finished product creates a shortage of consistent supplier (Baltussen 2019; Rathinamoorthy 2019; Kumar and Suganya 2019). The problem that may arise in supplier consistency is affected by the amount and frequency of supply and brands and retailers that want to produce in a CE is prevented (Mangla et al. 2018; Kumar and Suganya 2019.) In a CE system working with SC stakeholders who share the same vision is also difficult as many firms do not accept and deploy the CE. Thus, problems on losing control and trust are experienced frequently (Brown, Bocken, and Balkenende 2019; Karlsson, Rootzén, and Johnsson 2020). In order to act jointly within the SC, loss of control in the sharing of information about the CE and absence of trust among stakeholders such as manufacturers, designers, retail and brands, collectors, and recyclers arise as a barrier (Snoek 2017; Rizos et al. 2016; Jia et al. 2020). In addition, because the supply chain is formed by various stakeholders, effective risk management and decision-making systems should be created by including all stakeholders to handle potential errors (Cong et al. 2008)

Economic: 'High initial costs (C20)', 'vagueness in profit margins and rate of return (C21)', 'diseconomies of scale (C22)' are other barriers under economy. Textile manufacturers have to bear high investment costs in order to change their infrastructure and technologies in transition to CE. High capital investment is needed in order to have a technological infrastructure for the processes like reuse of returned products, recovery, and recycling in providing reverse logistics service and for the training of the personnel working in this field for manufacturers, collectors, and recyclers. The cost of sustainable raw material is also high compared to the virgin raw material used in the linear economy (Pheifer 2017; Pathak and Endayilalu 2019). These needs increase the initial investment cost and need for working capital (Rizos et al. 2016; Snoek 2017; de Jesus and Mendonça 2018; Pathak and Endayilalu 2019; Baltussen 2019; Patel and Desai 2019; Jia et al. 2020; Govindan and Hasanagic 2018; Hendiani, Liao, and Jabbour 2020). The return on investment is uncertain as it is cumbersome to identify and measure the long-range effects of the benefits of the CE by manufacturers, collectors, and recyclers. In addition, since the cash flow, income, and cost development of the new business model are not known by the companies, this model has been defined as a barrier in the short-term adoption of the CSC due to the lack of economic benefits (Rizos et al. 2015; Mangla et al. 2018; de Jesus and Mendonça 2018; Werning and Spinler 2020). Also, since virgin material costs are lower than sustainable products, brands and retailers want to produce and sell large quantities, so the concern about whether they can produce a large amount of circular products creates uncertainty in their profitability (Brink 2018). Due to the fact that technology in textile is not sufficiently developed, difficulties in recycling products cause these products to not be produced very much, which make the development of economies of scale difficult for collectors and recyclers. Moreover, as the demands of consumers and producers for recycled materials increase, fabrics will become more available and affordable owing to economies of scale (Brink 2018; Baltussen 2019; Kurkela 2020).

Infrastructural and technological: Combining and developing technologies to generate suitable raw materials from post-consumption textile waste and production waste is vital to close the loop (Pandit, Nadathur, and Jose 2019). However, technology may be insufficient for the collection, classification, and separation of textile wastes with the existing infrastructure of textile companies especially for collectors and recyclers (Boiten, Li-Chou Han, and Tyler 2017; Koszewska 2018; Dieckmann et al. 2020). Especially in emerging economies, these processes are carried out by informal waste sellers (Baltussen 2019; Filho et al. 2019). In addition, the complexity of the product contents makes separation difficult and technology is needed (Hawley 2014). Lack of recycling facilities at local and regional level with reverse logistics infrastructure in collecting textile waste makes it difficult to carry out circular activities (Rizos et al. 2016; Patel and Desai, 2019; Hart et al. 2019). Therefore, the lack of infrastructure makes it difficult to implement CSC in textile industry.

4. Methodology

Literature review was investigated to reveal CSC barriers within CE in textile industry. The expert opinions were taken by interviews. In this stage, the industrial experts have been formed. This is followed by a data collection stage where the data were collected from industrial experts using pairwise comparisons. Next, we applied Fuzzy DEMATEL method. Finally, the results of the proposed

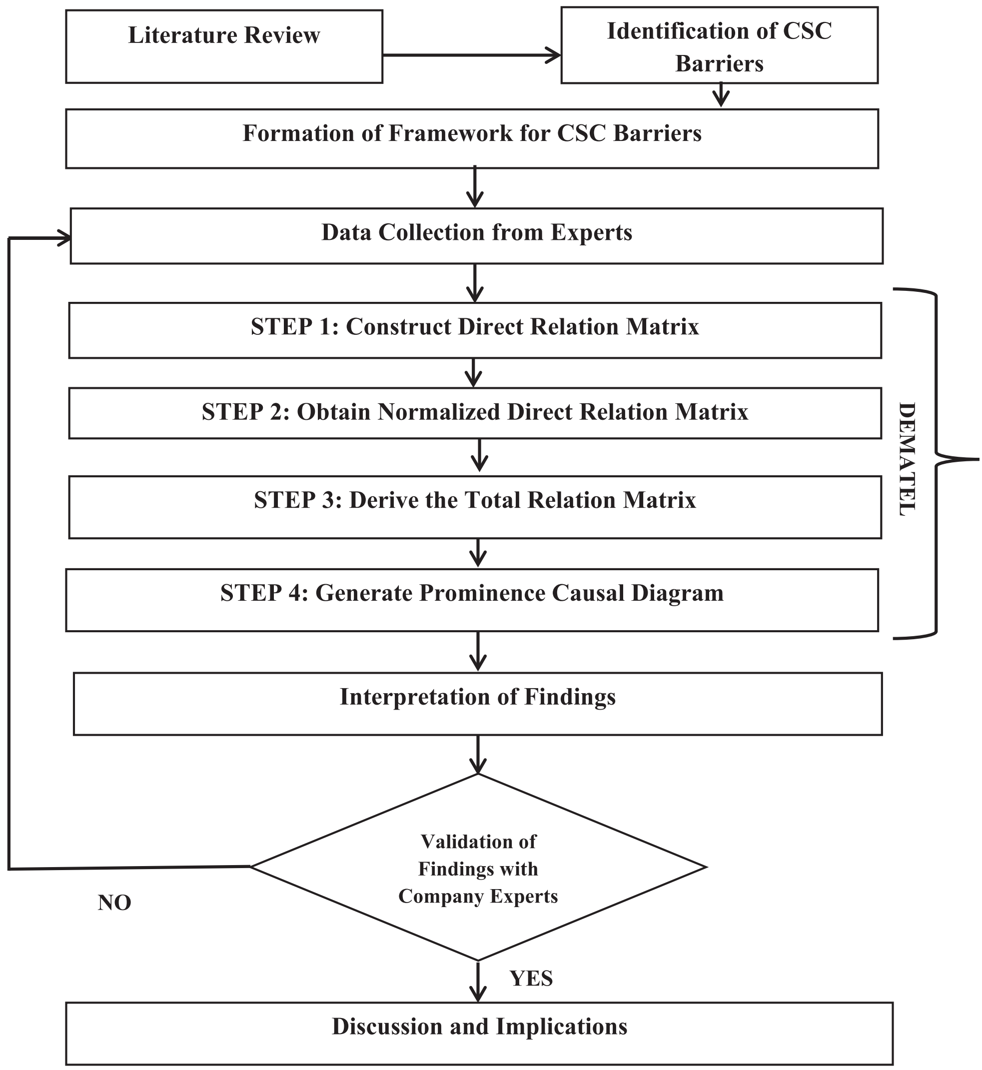

Figure 2. Proposed framework for analysing CSC barriers in textile industry.

framework are discussed, and implications were proposed. Figure 2 shows the proposed framework for this research.

The reason to hire fuzzy logic is due to its capability to deal with the vagueness in human judgment and subjectivity which are inherent within the human decision-making process. The reason to use DEMATEL method is due to the fact that it analyses a structured procedure to reveal cause & effect relationship among the specified factors (Fekri, Aliahmadi, and Fathian 2009). Fuzzy DEMATEL is a widely used technique for barrier studies to determine causal relationships (Kaur et al. 2018) including green and sustainable supply chains (Moktadir et al., 2020), CSC (Farooque et al. 2019). Fuzzy DEMATEL is useful in dealing with human bias and ambiguity involved in studying the interrelationships between barriers (Mangla et al. 2018). DEMATEL is a flexible model that can produce more reliable results with less data compared to other methods such as ISM and AHP (Yang and John 2003). Thus, in this paper, the DEMATEL technique is integrated with fuzzy logic to utilise the advantages of both in a decision-making process.

4.1. The fuzzy DEMATEL method

DEMATEL method is developed by the Battelle Memorial Institute through Genova Research Centre (Gabus and Fontela 1972, 1973). DEMATEL can be described as an extensive method for constructing and analysing the causal relationship among the complex factors in a structural model (Fekri, Aliahmadi, and Fathian 2009) and it gives priority to criteria depending on the relation type and the severity of the impact on others (Tseng and Lin 2009). Also, due to decision-makers are likely to make decisions depending on their personal experiences and thoughts, their evaluations are stated in equivocal linguistic terms (Fekri, Aliahmadi, and Fathian 2009). Therefore, the fuzzy theory is useful for dealing with the vagueness that is the nature of human thought and language in decision-making (Lin and Wu 2008).

The modified version of the DEMATEL method obtained by Fontela and Gabus (1976) presented as below (Wu and Lee 2007).

Definition 1: The pair-wise comparison scale by using an integer scale can be generated and categorised as follows, 'No influence', 'Low influence', 'High influence' and 'Very high influence' which corresponds to 0,1.2 and 3 respectively.

Definition 2: The initial direct-relation matrix 'Z', which is a (n x n) matrix, is derived by ranking the criteria in terms of influences and directions via pair-wise comparisons, in which z_{ij} is denoted as the rating that which criterion i affects the criterion j, i.e. $Z = [z_{ij}]_{\mathrm{nxn}}$.

Definition 3: The normalised direct-relation matrix 'X', e.g. $\mathrm{X} = [\mathrm{x_{ij}}]_{\mathrm{nxn}}$ and $0 \leq x_{ij} \leq 1$ can be obtained from the following formulas (1) and (2), where all major diagonal components are regarded as zero.

$$X = s \cdot Z \tag{1}$$

$$s = \frac{1}{\max_{1 \leq i \leq n} \sum_{j=1}^{n} z_{ij}}, \quad i, j = 1, 2, \ldots, n. \tag{2}$$

Definition 4: For the calculation of the total-relation matrix 'T', formula (3) can be used, in which the 'I' represents the identity matrix.

$$T = X(I - X)^{-1}. \tag{3}$$

Definition 5: The sum of both rows and columns are separately described as 'D' and 'R' respectively for the computing total-relation matrix 'T' by using formulas (4)–(6):

$$T = t_{ij},\ i,\ j = 1, 2, \ldots, n, \tag{4}$$

$$D = \sum_{j=1}^{n} t_{ij}, \tag{5}$$

$$R = \sum_{i=1}^{n} t_{ij}, \tag{6}$$

Definition 6: The cause–effect diagram can be derived by plotting the dataset of $(D + R, D - R)$, where the horizontal axis is computed as $(D + R)$, and the vertical axis can be generated as deducting D from R $(D - R)$.

4.2. The fuzzy logic

A successful approach to defuzzification must consider a fuzzy number identified by its form, spread, height, and relative position on the x-axis (Opricovic and Tzeng 2004). Centroid (Center-of-gravity) is regarded as the most widely used defuzzification method (Yager and Filev 1994), however, it cannot differentiate two fuzzy numbers that have the same crisp value in terms of different forms. Thus, Converting Fuzzy data into Crisp Scores (CFCS), is used to provide more crisp value than the Centroid method.

The CFCS method, which is devised by Opricovic and Tzeng (2004), depends on the method which calculates the right, medium, and left (l,m,r) scores by using fuzzy min and fuzzy max, and the weighted average has taken as regards to the membership function to compute the overall score. The indication of the fuzzy evaluation of the evaluator k (k = 1,2,. . ., p) shows a level to which of the criterion I influence criterion j. The CFCS method involves an algorithm that is comprised of five stages defined as follows:

(1) Normalisation:

$$xl_{ij}^k = (l_{ij}^k - \min l_{ij}^k)/\Delta_{\min}^{\max}, \tag{7}$$

$$xm_{ij}^k = (m_{ij}^k - \min l_{ij}^k)/\Delta_{\min}^{\max}, \tag{8}$$

$$xr_{ij}^k = (r_{ij}^k - \min l_{ij}^k)/\Delta_{\min}^{\max}, \tag{9}$$

where

$$\Delta_{\min}^{\max} = \max r_{ij}^k - \min l_{ij}^k.$$

(2) Compute left (ls) and right (rs) normalised value:

$$xls_{ij}^k = xm_{ij}^k/(1 + xm_{ij}^k - xl_{ij}^k), \tag{10}$$

$$xrs_{ij}^k = xr_{ij}^k/(1 + xr_{ij}^k - xm_{ij}^k). \tag{11}$$

(3) Compute total normalised crisp value:

$$x_{ij}^k = [xls_{ij}^k(1 - xls_{ij}^k) + xrs_{ij}^k xrs_{ij}^k]/[1 - xls_{ij}^k + xrs_{ij}^k]. \tag{12}$$

(4) Compute crisp values:

$$z_{ij}^k = \min l_{ij}^k + x_{ij}^k \Delta_{\min}^{\max}. \tag{13}$$

(5) Integrate crisp values:

$$z_{ij}^k = \frac{1}{p}(z_{ij}^1 + z_{ij}^2 + \cdots + z_{ij}^p). \tag{14}$$

4.3. The procedure of fuzzy DEMATEL method

The theoretical processes are clarified as following for the further applicability of the Fuzzy DEMATEL system for group decision-making:

Step 1: Forming an expert group for the identification of the decisive goal. An initial step is defining what the decision objectives are and set up an expert group to gather the experts to solve problems.

Step 2: Developing evaluation factors and designing the fuzzy linguistic scale. For addressing the equivocalness of human judgments, the linguistic variable, which is 'influence', with five linguistic

Table 2. Fuzzy linguistic scale.

Linguistic terms	Triangular fuzzy numbers
Very high influence (VH)	(0.75,1.0,1.0)
High influence (H)	(0.5,0.75,1.0)
Low influence (L)	(0.25,0.5,0.75)
Very low influence (VL)	(0,0.25,0.5)
No influence (No)	(0,0,0.25)

terms is used (Li 1999) which are denoted in positive triangular fuzzy numbers (lij, mij, rij) as shown in Table 2.

Step 3: Obtaining and combining the evaluations of decision-makers. Measurement of the interaction among the assessment variables $C = \{Ci \mid i = 1,2,\ldots, n\}$ is typically essential to ask an expert group to carry out an assessment composed of influences and directions among factors. Thereafter, the fuzzy evaluations taken from experts are defuzzied and reunited as a crisp value which is represented as z_{ij}. Lastly, the initial direct-relation matrix may be acquired from (7)–(14) formulas.

Step 4: Generating a structural model and analysing the diagram. The normalised direct-relation matrix X can be computing using formula (1) depending on the initial direct-relation matrix Z. After, the total-relation matrix T can be acquired via formula (3). The causal diagram formulas can be obtained from Definition 5 and 6, which are denoted as formulas (4)–(6). 'Prominence' which is the horizontal axis of the causal diagram described as (D + R), on the other side, causal diagram's vertical axis named 'Relation' can be calculated by deducting R from D as following formula (D−R). The horizontal axis which is indicated as 'Prominence' displays the significance level of the factors, where the 'Relation', the vertical axis, can separate factors as a cause–effect group. Typically, when there is a plus sign on the 'Relation' axis, this means that the factor can be taken as in the cause group. Accordingly, when the 'Relation' axis has a minus sign, this corresponds to that factors regarded as in the effect group.

5. Case study in the textile industry

In this study, the CSC barriers faced by the stakeholders in the SC towards the transition to the CE in the textile sector are evaluated. The reason to select textile industry is that it is one of the most polluting manufacturing industries that create several negative environmental impacts as follows: it excessively consumes resources such as oil, carbon, and water, it has high shares in carbon budget, and it increases levels of microfibres in oceans (Ellen MacArthur Foundation 2017). Due to the rising importance of zero waste and circular economy in the textile industry and the negative impacts of using linear economy in the textile industry, this study is focused on the textile industry. Moreover, since the circular economy in manufacturing contains the entire complex supply chain (Bianchini, Rossi, and Pellegrini 2019), the study is focused on the transition to circular supply chains in the textile industry.

Turkey is the sixth-largest producer for the apparel industry worldwide and the largest textile manufacturer in Europe. In 2017, Turkey is stated as the fifth largest exporter of textile products. Approximately one million people are employed in the textiles industry in Turkey (Sabanoglu 2019). The industry has the greatest foreign trade surplus and is the leading industry in the gross domestic product and domestic input use. The sector leads with high tech use, flexible production capability, and qualified workforce (Textile Focus 2019). The total amount of textile exports of Turkey was 763 million USD (Istanbul Textile and Raw Materials Exporters Association [ITRMEA] 2019). However, total exports of Turkish textile and raw materials decreased by 5.5% in 2019 compared to 2018, the amount of total textile and raw materials exports increased by 2% in 2019 (Yoleri 2020). On the other hand, as a global trend, the developed economies have preferred to outsource their domestic production process to emerging economies with low-wage costs, like

Turkey, where the SC is demand-driven and quite flexible (Snoek 2017). In the textile industry, certain manufacturers have relative power over the SC in the market with their size in the market and control the suppliers in the market (Kirchherr et al. 2018).

The interview technique was used in data collection. The stakeholders in SC in textile industry were interviewed. The interviews were started with a global retailer company. This global retailer was chosen because it is one of the leading global retailers in Turkey and the CE principles were strongly emphasised from product design to all SC processes in its sustainability report. In addition, the reason to begin interviews with a global retailer company is that a global retailer is the key entity in the textile SC that dominates and leads the whole SC stakeholders such as designers, raw material suppliers, manufacturers, and local retailers.

The reason for collecting data in this way is that CSC in textile industry is a recent and new research field within CE that requires in-depth expertise and CSC has just been started to be implemented in Turkish textile industry.

The advice of experts in this field was used to figure out the companies to be included in the study. The companies are determined by perceiving the goal of representing the forward and reverse flows in the circular textile SC. Thus, the parties of the CSC studied in this study consist of recycling companies, raw material suppliers, final product manufacturers, retailers, and finally the government side as the policymakers. Therefore, in the study, one global retailer brand, one textile recycler, two raw material suppliers, one reverse logistics company, one design agency, three garment manufacturers, and two government authorities are included as shown in Table 3.

Data were collected from 11 experts, representing the stakeholders in the SC, using pairwise comparisons. Nine experts have been working in the companies that take place directly in the supply chain such as retailer, textile recycler, raw material supplier, and final product manufacturer. They have been working in different positions related to sustainability such as sustainable development manager, environmental engineer, and director of sustainability.

The other two experts have been working in the governmental and policymaker agency, named as Aegean Exporter's Associations. They were included to the research in order to understand the governmental and non-profit organisations' perspectives regarding sustainability and circularity in the textile industry. They have seen as an expert in this field because they work as foreign trade and marketing specialists and are responsible for increasing regional developments in exporting of raw textile materials, specifying the strategies about production and marketing capabilities for a sustainable textile industry, making statistical analysis of the textile industry, executing market researches, and organising fashion design contests to promote the design culture.

Among the 11 experts, most of them were graduated from the Faculty of Business and Faculty of Engineering, few of them also earned PhD and MBA degrees. The ages of the experts were distributed between 36 and 62. They have worked in many different positions and companies before, and

Table 3. Information about industrial experts.

Position in the supply chain	Expert's position	No. of years in the company	Total work years	Gender
Global Brand and Retailer	Vice President Supply Chain	18	22	Female
Textile Recycler	General Manager	23	25	Male
Raw Material Supplier: Yarn Manufacturer	Sustainable Development Manager	7	10	Male
Raw Material Supplier: Fabric manufacturer	Senior Environmental Engineer	8	11	Male
Final product manufacturer:	Owner	14	23	Female
Garment manufacturer	Export Operations and Business	7	10	Male
	Director of Sustainability	21	23	Male
	R&D Engineer	6	7	Female
	Director of Sustainability	8	12	Female
Governmental and	Secretary General	15	20	Female
Policy Maker	Head of Textile Garment Department	11	13	Male

now they have been working in the relevant company, which this research was executed in, for many years. The shortest time period in the relevant company was 6 years, despite the longest time in the relevant company was 23 years. The details can be seen in Table 3. These experts have been included in the research because of their experiences and long working years in the field that is between 7 and 25 years. After collecting data, the steps of the DEMATEL method explained above were applied in data analysis.

6. Results

The DEMATEL results have indicated the following results and findings based on three categories which are cause and effect groups and importance group. Table 4 exhibits the Direct Relation Matrix, X, and Table 5 presents the Total Relation Matrix.

The row totals (D) and column totals (R) of Total Relation Matrix are calculated using Equations (4)–(6), respectively. The results are exhibited with a graph to visualise in a cause–effect diagram. The (D + R) values show the importance level and represented on the horizontal axis, whereas the (D−R) values identify whether the criterion belongs to the cause or effect group and represented on the vertical axis. A positive (D−R) value represents that the criterion belongs to the cause group whereas a negative (D−R) value represents that the criterion belongs to the effect group (Wu and Lee 2007).

The cause group represents the factors influencing the other factors. The cause group members are located above the horizontal axis. As the distance from the horizontal axis increases it signals a greater influence of that factor to others.

The effect group represents the factors being influenced by other factors. The effect group members are located below the horizontal axis. As the distance from the horizontal axis increases, it exhibits that the factor is being influenced more than other factors.

The importance group represents the factors influencing and being influenced simultaneously. The important group members are located on the vertical axis. As the distance from the vertical axis increases it mentions greater importance of the factor.

According to the definitions given above, the following findings are listed according to the results shown in Figure 3. The three barriers with the highest cause values are listed respectively as: ‘Lack of technical knowledge’ (C16), ‘Procurement problems for recyclable materials’ (C8), and ‘Lack of

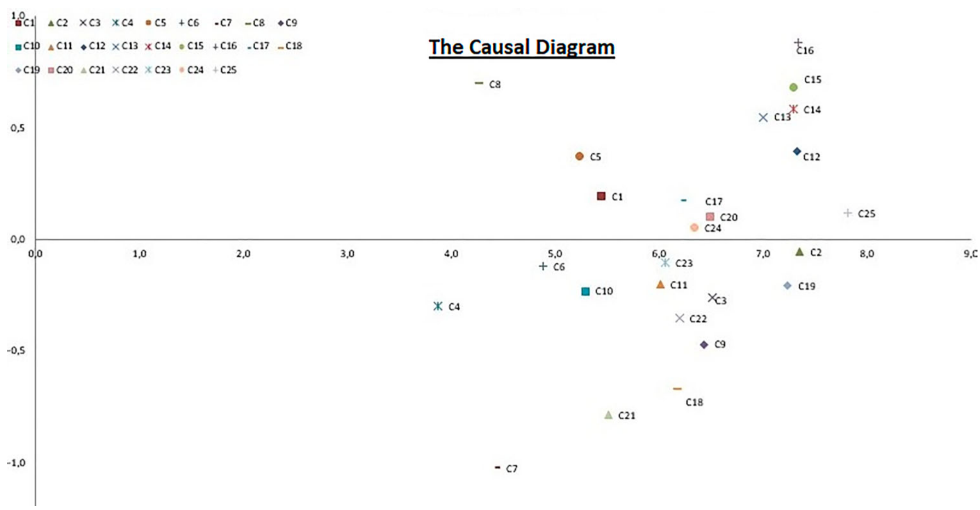

Figure 3. Causal diagram.

Table 4. Direct Relation Matrix, X.

	DEMATEL																								
X	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25
C1	0,00	0,04	0,04	0,02	0,03	0,02	0,02	0,02	0,03	0,02	0,02	0,03	0,03	0,03	0,04	0,03	0,04	0,04	0,05	0,03	0,03	0,03	0,01	0,02	0,02
C2	0,04	0,00	0,04	0,03	0,03	0,03	0,03	0,02	0,04	0,02	0,03	0,05	0,04	0,04	0,05	0,05	0,04	0,03	0,05	0,04	0,04	0,04	0,04	0,04	0,04
C3	0,03	0,03	0,00	0,03	0,03	0,02	0,01	0,02	0,04	0,02	0,03	0,05	0,04	0,04	0,03	0,03	0,04	0,04	0,04	0,02	0,03	0,03	0,03	0,03	0,03
C4	0,02	0,03	0,02	0,00	0,04	0,01	0,01	0,01	0,02	0,02	0,02	0,01	0,02	0,01	0,01	0,01	0,02	0,01	0,02	0,02	0,01	0,01	0,02	0,02	0,04
C5	0,03	0,03	0,02	0,03	0,00	0,02	0,02	0,01	0,03	0,02	0,02	0,03	0,02	0,04	0,04	0,04	0,03	0,03	0,03	0,03	0,02	0,02	0,03	0,03	0,04
C6	0,02	0,03	0,02	0,02	0,02	0,00	0,04	0,02	0,03	0,03	0,03	0,02	0,02	0,03	0,02	0,02	0,02	0,02	0,03	0,03	0,02	0,03	0,02	0,02	0,02
C7	0,01	0,02	0,02	0,02	0,02	0,02	0,00	0,02	0,02	0,02	0,02	0,01	0,02	0,01	0,02	0,02	0,01	0,01	0,02	0,01	0,01	0,02	0,01	0,02	0,03
C8	0,01	0,02	0,02	0,01	0,01	0,02	0,02	0,00	0,03	0,04	0,04	0,02	0,03	0,02	0,02	0,02	0,01	0,02	0,03	0,03	0,03	0,03	0,02	0,03	0,05
C9	0,03	0,04	0,03	0,01	0,03	0,03	0,04	0,01	0,00	0,03	0,04	0,04	0,03	0,03	0,02	0,02	0,03	0,05	0,03	0,04	0,04	0,03	0,02	0,02	0,04
C10	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,02	0,00	0,04	0,02	0,02	0,02	0,02	0,02	0,01	0,03	0,02	0,03	0,03	0,03	0,03	0,03	0,05
C11	0,01	0,03	0,02	0,02	0,01	0,02	0,03	0,02	0,03	0,04	0,00	0,03	0,03	0,03	0,03	0,02	0,02	0,04	0,04	0,04	0,04	0,04	0,03	0,03	0,04
C12	0,04	0,05	0,05	0,02	0,02	0,04	0,04	0,02	0,05	0,04	0,04	0,00	0,05	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04
C13	0,04	0,04	0,06	0,02	0,03	0,04	0,04	0,03	0,05	0,04	0,03	0,05	0,00	0,04	0,04	0,04	0,03	0,04	0,04	0,03	0,03	0,04	0,04	0,04	0,05
C14	0,04	0,05	0,04	0,03	0,05	0,04	0,03	0,02	0,04	0,03	0,03	0,04	0,04	0,00	0,05	0,05	0,05	0,05	0,05	0,04	0,04	0,04	0,03	0,03	0,04
C15	0,04	0,05	0,04	0,03	0,04	0,04	0,04	0,03	0,04	0,04	0,04	0,05	0,04	0,05	0,00	0,05	0,05	0,05	0,05	0,03	0,04	0,03	0,03	0,03	0,04
C16	0,04	0,05	0,04	0,02	0,04	0,04	0,04	0,04	0,05	0,03	0,04	0,05	0,04	0,05	0,05	0,00	0,04	0,04	0,04	0,04	0,03	0,04	0,04	0,04	0,05
C17	0,03	0,03	0,04	0,02	0,02	0,03	0,03	0,02	0,02	0,02	0,02	0,04	0,03	0,04	0,04	0,04	0,00	0,04	0,05	0,03	0,03	0,03	0,03	0,03	0,04
C18	0,02	0,03	0,03	0,01	0,01	0,01	0,02	0,01	0,04	0,02	0,03	0,04	0,04	0,04	0,03	0,03	0,04	0,00	0,04	0,01	0,03	0,03	0,02	0,02	0,03
C19	0,03	0,04	0,04	0,01	0,02	0,03	0,02	0,01	0,04	0,03	0,03	0,04	0,04	0,05	0,04	0,05	0,05	0,04	0,00	0,03	0,03	0,04	0,04	0,03	0,05
C20	0,02	0,04	0,03	0,02	0,01	0,02	0,03	0,01	0,03	0,02	0,03	0,03	0,03	0,04	0,04	0,04	0,03	0,04	0,05	0,00	0,05	0,04	0,04	0,05	0,05
C21	0,02	0,04	0,03	0,01	0,01	0,02	0,01	0,01	0,03	0,02	0,02	0,02	0,01	0,03	0,02	0,02	0,02	0,03	0,04	0,04	0,00	0,04	0,04	0,03	0,03
C22	0,02	0,05	0,02	0,01	0,01	0,02	0,01	0,00	0,03	0,02	0,04	0,03	0,03	0,02	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,00	0,04	0,05	0,04
C23	0,01	0,04	0,04	0,03	0,02	0,02	0,02	0,01	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,00	0,04	0,05
C24	0,03	0,04	0,03	0,03	0,02	0,02	0,02	0,01	0,04	0,03	0,04	0,04	0,03	0,02	0,03	0,03	0,03	0,03	0,04	0,04	0,03	0,04	0,05	0,00	0,05
C25	0,03	0,04	0,05	0,04	0,04	0,02	0,03	0,03	0,04	0,05	0,05	0,04	0,04	0,03	0,04	0,04	0,03	0,04	0,04	0,05	0,04	0,05	0,05	0,05	0,01

Table 5. Total relation matrix, *T*.

	T																									
T	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	D's
C1	0,07	0,14	0,13	0,07	0,09	0,09	0,10	0,07	0,13	0,09	0,11	0,13	0,12	0,13	0,13	0,12	0,12	0,13	0,15	0,12	0,12	0,12	0,10	0,10	0,13	**2,82**
C2	0,14	0,14	0,16	0,11	0,12	0,12	0,13	0,08	0,16	0,12	0,14	0,17	0,16	0,17	0,16	0,16	0,15	0,16	0,18	0,16	0,15	0,16	0,15	0,15	0,18	**3,65**
C3	0,11	0,15	0,11	0,09	0,10	0,09	0,10	0,08	0,14	0,11	0,13	0,16	0,14	0,14	0,14	0,13	0,13	0,14	0,15	0,12	0,13	0,13	0,13	0,13	0,15	**3,13**
C4	0,06	0,09	0,08	0,04	0,08	0,06	0,06	0,04	0,08	0,07	0,07	0,08	0,08	0,07	0,07	0,07	0,07	0,07	0,08	0,08	0,07	0,07	0,08	0,07	0,10	**1,79**
C5	0,10	0,14	0,12	0,09	0,07	0,09	0,10	0,06	0,13	0,10	0,10	0,12	0,11	0,14	0,13	0,13	0,12	0,12	0,14	0,11	0,11	0,11	0,11	0,11	0,14	**2,80**
C6	0,08	0,12	0,10	0,07	0,08	0,06	0,10	0,07	0,11	0,09	0,11	0,10	0,10	0,10	0,10	0,10	0,09	0,10	0,12	0,10	0,10	0,10	0,09	0,09	0,11	**2,38**
C7	0,06	0,08	0,07	0,05	0,06	0,06	0,05	0,05	0,08	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,06	0,07	0,08	0,07	0,07	0,07	0,06	0,07	0,09	**1,70**
C8	0,08	0,11	0,11	0,06	0,07	0,08	0,09	0,04	0,11	0,11	0,12	0,11	0,11	0,11	0,10	0,10	0,09	0,10	0,12	0,11	0,11	0,11	0,10	0,11	0,14	**2,48**
C9	0,11	0,15	0,13	0,08	0,10	0,10	0,11	0,07	0,10	0,11	0,13	0,14	0,13	0,13	0,12	0,11	0,12	0,15	0,14	0,13	0,13	0,13	0,11	0,12	0,15	**2,98**
C10	0,08	0,11	0,11	0,07	0,08	0,09	0,10	0,07	0,11	0,07	0,12	0,11	0,10	0,10	0,10	0,10	0,09	0,11	0,12	0,11	0,10	0,11	0,10	0,11	0,14	**2,53**
C11	0,09	0,14	0,12	0,08	0,08	0,10	0,11	0,07	0,13	0,11	0,09	0,13	0,12	0,13	0,12	0,12	0,11	0,14	0,14	0,13	0,13	0,13	0,12	0,12	0,15	**2,90**
C12	0,14	0,19	0,18	0,10	0,11	0,13	0,14	0,09	0,18	0,14	0,15	0,13	0,17	0,17	0,17	0,17	0,15	0,17	0,18	0,16	0,16	0,17	0,16	0,16	0,19	**3,86**
C13	0,13	0,18	0,18	0,10	0,12	0,13	0,14	0,10	0,17	0,14	0,15	0,18	0,12	0,16	0,16	0,16	0,15	0,17	0,18	0,15	0,15	0,16	0,16	0,15	0,19	**3,78**
C14	0,14	0,19	0,17	0,11	0,14	0,14	0,13	0,09	0,18	0,14	0,15	0,18	0,17	0,13	0,18	0,17	0,16	0,18	0,20	0,16	0,16	0,17	0,15	0,15	0,19	**3,94**
C15	0,15	0,19	0,18	0,11	0,14	0,13	0,15	0,10	0,17	0,15	0,16	0,19	0,17	0,18	0,13	0,18	0,17	0,18	0,20	0,16	0,16	0,16	0,15	0,16	0,19	**3,99**
C16	0,14	0,20	0,18	0,11	0,14	0,14	0,15	0,11	0,19	0,15	0,17	0,19	0,17	0,19	0,19	0,13	0,16	0,18	0,19	0,17	0,16	0,17	0,16	0,17	0,20	**4,11**
C17	0,11	0,15	0,15	0,08	0,10	0,11	0,12	0,07	0,13	0,11	0,12	0,15	0,14	0,15	0,15	0,14	0,10	0,15	0,17	0,13	0,13	0,13	0,13	0,13	0,16	**3,20**
C18	0,10	0,13	0,13	0,07	0,08	0,08	0,09	0,06	0,13	0,10	0,12	0,13	0,13	0,13	0,12	0,12	0,12	0,10	0,14	0,10	0,11	0,12	0,10	0,10	0,13	**2,75**
C19	0,12	0,17	0,16	0,09	0,11	0,11	0,12	0,08	0,16	0,12	0,13	0,16	0,15	0,16	0,16	0,16	0,16	0,16	0,13	0,14	0,14	0,15	0,14	0,14	0,18	**3,51**
C20	0,11	0,17	0,14	0,09	0,09	0,10	0,12	0,07	0,14	0,11	0,13	0,14	0,14	0,15	0,14	0,14	0,13	0,15	0,17	0,11	0,15	0,15	0,14	0,15	0,17	**3,29**
C21	0,08	0,13	0,10	0,06	0,07	0,08	0,08	0,05	0,11	0,08	0,09	0,10	0,09	0,10	0,10	0,10	0,09	0,11	0,12	0,11	0,07	0,11	0,11	0,11	0,12	**2,36**
C22	0,09	0,16	0,12	0,07	0,08	0,09	0,09	0,06	0,13	0,10	0,13	0,13	0,13	0,12	0,12	0,12	0,12	0,13	0,15	0,13	0,13	0,10	0,13	0,14	0,15	**2,92**
C23	0,09	0,14	0,14	0,09	0,09	0,09	0,10	0,07	0,13	0,11	0,12	0,14	0,12	0,13	0,13	0,13	0,12	0,13	0,14	0,13	0,13	0,13	0,09	0,14	0,16	**2,98**
C24	0,11	0,16	0,14	0,09	0,09	0,10	0,11	0,07	0,15	0,11	0,14	0,15	0,14	0,13	0,14	0,13	0,12	0,14	0,16	0,14	0,13	0,14	0,14	0,10	0,17	**3,19**
C25	0,13	0,18	0,18	0,13	0,14	0,12	0,14	0,10	0,18	0,16	0,17	0,18	0,16	0,16	0,17	0,17	0,15	0,17	0,18	0,17	0,16	0,18	0,17	0,17	0,16	**3,96**
R's	**2,62**	**3,70**	**3,39**	**2,09**	**2,43**	**2,50**	**2,73**	**1,79**	**3,45**	**2,76**	**3,11**	**3,47**	**3,23**	**3,35**	**3,31**	**3,23**	**3,03**	**3,42**	**3,72**	**3,19**	**3,15**	**3,27**	**3,08**	**3,14**	**3,85**	
D's	**2,82**	**3,65**	**3,13**	**1,79**	**2,80**	**2,38**	**1,70**	**2,48**	**2,98**	**2,53**	**2,90**	**3,86**	**3,78**	**3,94**	**3,99**	**4,11**	**3,20**	**2,75**	**3,51**	**3,29**	**2,36**	**2,92**	**2,98**	**3,19**	**3,96**	

theoretical knowledge' (C15) whereas; the three barriers with the highest effect values are listed respectively as: 'Challenges in product design' (C7), 'Vagueness in profit margins and rate of return' (C21), and 'Supplier inconsistency' (C18).

The three barriers with the highest importance values are listed respectively as: 'Lack of collecting, sorting and recycling' (C25), 'Reluctance for acceptance of CE model' (C2), and 'Problems related to uniformity and standardisation' (C12)

In order to make a more in-depth analysis to elaborate findings, the one to one cause and effect relationships among the leading barriers in each category are studied here.

The barrier with the highest cause value is 'Lack of technical knowledge' (C16) is influencing the following two barriers more than others; 'Lack of collecting, sorting, and recycling' (C25) and 'Reluctance for acceptance of CE' (C2). The barrier with the second highest cause value is 'Lack of theoretical knowledge' (C15) is influencing the following two barriers more than others: 'Lack of vision and trust' (C19) and 'Lack of acceptance of new business models' (C2). The barrier with the third highest cause value is 'Procurement problems for recyclable materials' (C8) is influencing the following two barriers more than others: 'Lack of collecting, sorting, and recycling' (C25) and 'High raw material costs (C11)'.

The barrier with the highest effect value is 'Challenges in product design' (C7) is being influenced by the following two barriers more than others: 'Lack of theoretical knowledge' (C15) and 'Lack of technical knowledge' (C16). The barrier with the second highest effect value is 'Uncertainty in profitability and return on investment' (C21) is being influenced by the following two barriers more than others: 'Lack of collecting, sorting, and recycling' (C25) and 'Lack of awareness' (C14). The barrier with the third highest effect value is 'Supplier inconsistency' (C18) is being influenced by the following two barriers more than others: 'Lack of theoretical knowledge' (C15) and 'Lack of technical knowledge' (C16).

To validate the findings, an interview method is conducted with the experts, who were involved in sustainable SC operations to figure out whether the results are in line with their current problems. The findings and results of this paper were found in line to the expectation of the industrial experts. Then, some implications were developed.

7. Discussion

'Lack of collecting, sorting and recycling' (C25) is revealed as the barrier with highest most importance due to the fact that it has the most significant relation among all factors. This is in parallel with the findings of Baltussen (2019) study stated that waste textile materials collection, sorting and separation systems should be developed for better treatment of recycled textile waste. Paletta et al. (2019) emphasised that the collection and classification of the PET bottle have become increasingly important to ensure the continuity of the secondary raw material production volume. At the same time, as Pasqualotto (2015) stated that another problem in collection and sorting is that this process is done by informal institutions. Sandvik (2017) emphasised that even if attempts/initiatives are set for textile recycling, this is a technological barrier because there is not enough separation technology to support this recycling system. As many academics mentioned that an important barrier in transition to circular textile is the lack of technology (Elander and Ljungkvist 2016). Besides, it is stated that the regional infrastructure shortage is a primary factor, which will further increase this collection and sorting problem, which is an important barrier (Tura et al. 2019).

'Reluctance for acceptance of CE' (C2) and 'Problems related to uniformity and standardisation' (C12) are the second and third most important barriers, respectively. Kirchherr et al. (2018), as stated in the study, all companies in the SC should adopt the CE model in the formation of the CSC. As Tura et al. (2019) point out the fact that some of the stakeholders within the network are not willing to adopt the new business model and that the corporate culture does not support the companies in this direction is considered as an important barrier. Therefore, adopting the linear economy model is an important barrier for this type of company. In Roosendaal (2018) study stated that the presence of companies doing business in the linear system ranks fourth among the most effective barriers in the transition to the CE on textile industry. Besides, Kirchherr et al. (2017) underlined that the lack of standardisation is a crucial barrier within the transition to CE. Lack of metrics and standards for recycled product and production standardisation also creates a significant barrier in terms of material efficiency (Hart et al. 2019).

'Lack of technical knowledge' (C16) is the most influencing factor, placed at the top of the Cause Group. As a result of Moktadir et al. (2020) study on the leather industry in Bangladesh, it has been determined that lack of awareness and information, as in this study, is the most important causal barrier to transition to CE. Snoek (2017), Muradin and Foltynowicz (2019) stated that the lack of academic and feasible information about the CE principles is a barrier to the CE. The lack of information regarding implementing CE, especially about the benefits of the CE for companies, is the biggest barrier for companies to invest and implement the CE (Herrero Rodríguez 2017). As stated in the study of Pasqualotto (2015), companies do not have sufficient technical information, knowledge, and managerial capacity for companies to change their current business models and implement the CE. In addition to the lack of information, education programme is a critical barrier in the implementation of sustainable production (Malek and Desai 2019). Likewise, Rizos et al. (2015) and Tura et al. (2019) emphasised that the lack of technical and managerial knowledge and skills is an important barrier especially in the adoption of the CE business model of SMEs. Lack of technical knowledge especially how to replace existing virgin materials with recyclable material is questionable (Roosendaal 2018). In addition, a limited level of knowledge makes it difficult to offer quality circular products to the market. Therefore, to have insufficient technical knowledge, it will create deficiencies in the identification, evaluation of the products, and application of the production (Rizos et al. 2016; Tura et al. 2019).

'Challenges in product design' (C7) is the most influenced factor, at the bottom of the Effect Group. This is in accordance with the findings of the following studies. Govindan and Hasanagic (2018) stated that the complex product structure poses a major barrier for manufacturers and recyclers such as garment manufacturers and recyclers in textile CSC. Due to the fact that the product will be difficult to remanufacture and reuse, it must be designed with a circular economic model from the first design. Eco design and production make it more difficult as there is insufficient investment in environmentally friendly technologies that can achieve this (Rizos et al. 2016). Another challenge is, as Franco (2017) points out, the number of component parts and ecological alternatives available in the market for the production and supply of products in the CE.

8. Research implications

The barrier with the highest cause value is 'Lack of technical knowledge' (C16). It states the need for technical knowledge and know-how. The recycling process of textile products requires significant knowledge as well as know-how due to the variety of components and materials existing within the process. The support and commitment of top management are required to allocate the necessary financial resources towards know-how investments. Thus, the awareness of top management on circular processes should be increased. Meanwhile, the companies should realise the need for the transition to CE. Hence, the current business models should change and transform to new business models. In addition, the human resources related to the circular operations may be trained for the know-how and use of related technologies on circular operations. Thus, the following stakeholders may increase their technical knowledge about CE in their processes such as fibre, yarn, fabric, and garment manufacturers in their production processes, designers in their circular product design and, collectors and recyclers to implement recent technologies.

The barrier with the second-highest cause value is 'Lack of theoretical knowledge' (C15). This barrier implies the need to incorporate the CE concept and its related stages throughout the manufacturing and SC activities. The necessary theoretical knowledge is essential to implement the above-mentioned technical know-how. Therefore, the cooperation and collaboration of textile industry with universities is necessary to constitute the theoretical knowledge within the company and among the partners within the CSC. At the same time, industry, academia, non-governmental organisations may work together through research projects and programmes may concentrate to improve theoretical information and technical know-how (Koszewska 2018). Thus, the manufacturers, designers, collectors, and recyclers may be engaged with continuous improvement by means of education and training in order to enhance their theoretical knowledge.

The barrier with the third-highest cause value is 'Procurement problems for recyclable materials' (C8). Certain parts and components of products cause them to be unsuitable for recycling. As an example, the metals and petroleum-based plastics in textile products are an obstacle for recycling. Thus, the need for circular design arises as the managerial implication in this stage. Hence, with the aid of circular design the proportion of recyclable materials within the product can be increased. In addition to that, the technological innovations and research may be conducted to decrease the adverse effect of availability of recyclable materials in the future. On the other hand, the end-users may be encouraged and motivated to join the CE by using collection bins to throw their textile products. In addition, the collectors and recyclers may be subsidised by the government. In that way, the continuous flow of recycled materials will contribute to the capacity usage of manufacturers.

There are also implications for policymakers related to the leading cause group members. Initially, government support is essential to transform textile industry from linear to CE and to sustain circular implementations. The government may encourage the technology transfer to eliminate lack of technical information in order to implement CE. This is possible via subsidising the transfer of know-how, stating incentives and tax exemptions. In addition to that, the government and local authorities can increase the awareness of textile companies on the benefits of CE and its contributions to sustainability. The government and local authorities may state rules and regulations on product standards and components to increase the availability of recyclable materials.

The barrier with the highest effect value is 'Challenges in product design' (C7). At the design stage the products are not designed according to the principles of circular economy and circular business models. The availability of basic materials or component parts complements architectural innovation. Components have to be separated, classified, and recycled without loss of quality. Thus, as indicated before circular design should be based on the increasing availability of recyclable materials in the design stage. Therefore, the designers, brands, and retailers are the most critical points to implement designs based on circular principles because their performance will directly affect the success of the whole CSC (Cao et al. 2008; Dahlbo et al. 2017).

The barrier with the second-highest effect value is 'Vagueness in profit margins and rate of return' (C21). This is mainly due to the high investments required for the transfer of know-how and technology to manufacturers as well as to collectors and recyclers. The companies may overcome this difficulty by sharing resources with other firms or by using leasing options. On the other hand, the continuity of demand is an important factor for companies to get use of economies of scale and get rid of the vagueness on the feasibility of the circular activities. Especially brands and retailers approach the circular products with a question mark due to the vagueness in the sales volume and profit margin of the circular textile products. In that sense, policymakers can regulate the sector by enforcing the use of circular components and materials through laws, regulations, and incentives. In addition, the awareness of the consumers who generate the demand for circular textile products should be increased by the cooperation of Non-Governmental Organisations (NGO), government, and local authorities. Therefore, the upstream of SC may be enhanced to minimise uncertainty in profitability and return on investment.

The barrier with the third-highest effect value is 'Supplier inconsistency' (C18). This lack of consistency arises due to problems faced by the manufacturers on the quality and volume of the circular raw materials and components gathered from the collectors and recyclers. Especially, the lack of infrastructures on collection and classification may be covered by the investments of the government that will guarantee the supply of the circular materials with the required quantity. On the other hand, the suppliers may be trained and educated both by the government and the industry may enforce the use of certified suppliers to enhance the quality of circular components and raw materials. Thus, the downstream of SC may be improved in terms of quality and quantity to sustain constant suppliers and consistent flow of materials to producers.

The barrier with the highest importance value is ‘Lack of collecting, sorting and recycling’ (C25). This statement highlighted the importance of two stakeholders: collectors and recyclers. This is due to the lack of information on the collection and classification of textile waste in the transition of the textile sector to the CE (Rathinamoorthy 2019). As indicated above, the whole SC should be analysed and the necessary infrastructural facilities are built by the government. In addition, certified collection and separation may be established by the government as a regulatory measure to prevent the unofficial collection and to reduce related inefficiencies. In addition to that, in terms of managerial implication, the circular clusters for textile can be proposed.

The barrier with the second-highest important value is ‘Reluctance for acceptance of CE’ (C2). It is due to the hesitation of companies towards circular transition and circular business models. Thus, the hesitant company culture may be changed. This hesitation has also been triggered by the uncertainty in profitability and return on investment (Werning and Spinler 2020). Therefore, the top management should lead this transformation by focusing on the company culture. In this process, it may be the best solution for retailers and their suppliers to work together in improving resource utilisation and adoption of the circular economic model. In addition, the government and policymakers may also be considered to disseminate the CE principles among the textile CSC.

The barrier with the third-highest important value is ‘Problems related to uniformity and standardisation’ (C12). The standardisation is an important factor for circular textile operations. As indicated before, the standardisation is necessary especially for the design phase where standardised components and raw materials are required. This will also enhance production as well as SC operations. The concept of standardisation will also enhance the quality of circular products (Baltussen 2019; Luthra, Mangla, and Yadav 2019). On the other hand, the standardisation concept shall be extended to certification where the upstream and downstream activities within CSC can be unified and standardised. In addition, the government and policymakers may also be active to establish the standardisation and to sustain it by means of assessments and controls among the textile CSC.

9. Conclusion

Textile companies need all SC stakeholders to be circular in order to deliver a circular product. Today, it is not enough for a single textile company to adapt the CE. All stakeholders in the CSC have to adopt the CE principles. Since the textile SC is complex and long, it is not easy to implement the CE across the entire SC. There are some barriers faced by textile companies and all stakeholders faced these barriers in the transition to the CSC. Eliminating CSC barriers and increasing the adaptability to the CE have a vital importance for the sustainability of the textile companies. Therefore, in the textile industry, the CSC barriers may be investigated throughout the entire SC by considering the stakeholders. Among the stakeholders, retailers and brand owners trigger the need for circular supply chains because they play an active role in promoting and creating awareness within the supply chain for the CE transition. Retailers require their suppliers to design and produce according to the principles of circular economy and it is reflected all through the supply chain, on the other hand, the retailers can contribute to turn the consumer into a conscious consumer on circular fashion by creating circular product collections and creating awareness.

The contribution of the study is proposing the barriers in the textile CSC and encompassing all stakeholders in CSC with a holistic approach from design to production, retailers to recyclers. In addition, the study reveals the importance of barriers and categorises them as cause and effect groups. In this study, the transition to the CSC in the textile industry is discussed within the perspectives of barriers and stakeholders. It provides comprehensive directions for textile companies’

CSC by emphasising 25 barriers, under 9 categories, and revealing the corresponding stakeholders at each barrier. This study illustrates the cause and affects relationships among barriers by using Fuzzy DEMATEL.

According to the findings, 'Lack of collecting, sorting and recycling' (C25) is revealed as the most important barrier because it has the most significant relationship among all factors. 'Reluctance for acceptance of CE model (C2)', and 'Problems related to uniformity and standardisation (C12)' are the second and third most important barriers, respectively. 'Lack of technical knowledge' (C16) is the most influencing factor, located at the top of the Cause Group. 'Challenges in product design' (C7) is the most influenced factor, located at the bottom of the Effect Group.

There are some limitations to the study. The study examined only the CSC barriers. In literature, there are some other barriers such as economical, organisational, governmental, technological, and cultural. It is advised to conduct research regarding these barriers in the textile industry in the future. The other limitation is that this study is conducted in an emerging economy like Turkey, thus the results may differ in case of other developing countries such as India, Malaysia, Pakistan, Indonesia. The last limitation of this study is that it only focuses on barriers; however, future research can investigate the drivers of CSC.

In future research, other Multi-Criteria Decision Making methods (MCDM) such as analytic network process (ANP), analytic hierarchy process (AHP), or new qualitative researches could be conducted to understand the insights of industrial experts regarding the barriers. Last, the SC barriers are analysed specifically for the textile industry. Similar studies regarding different industries, such as food, can be conducted in further studies. In addition, the interest and awareness of the end-users on the CE, and their acceptance towards recycled textile products could be scrutinised.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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References

Atlason, R. S., D. Giacalone, and K. Parajuly. 2017. "Product Design in the Circular Economy: Users' Perception of End-Of-Life Scenarios for Electrical and Electronic Appliances." *Journal of Cleaner Production* 168: 1059–1069. doi:10.1016/j.jclepro.2017.09.082.

Ballie, J., and M. Woods. 2018. "Circular by Design: A Model for Engaging Fashion/Textile SMEs with Strategies for Designed Reuse." *Unmaking Waste in Production and Consumption: Towards the Circular Economy* 103.

Baltussen, A. M. 2019. "Mainstreaming Recycled Textiles: An Analysis of Drivers and Barriers for Circular Business Model Diffusion in the Dutch Apparel Industry", Master's Thesis Internship – Master Sustainable Business and Innovation Faculty of Geosciences, Utrecht University.

Bastein, T., E. Roelofs, E. Rietveld, and A. Hoogendoorn. 2013. "Opportunities for a Circular Economy in the Netherlands". TNO, Report commissioned by the Netherlands Ministry of Infrastructure and Environment, 1–13.

Batista, L., Y. Gong, S. Pereira, F. Jia, and A. Bittar. 2019. "Circular Supply Chains in Emerging Economies–a Comparative Study of Packaging Recovery Ecosystems in China and Brazil." *International Journal of Production Research* 57 (23): 7248–7268. doi:10.1080/00207543.2018.1558295.

Bianchini, A., J. Rossi, and M. Pellegrini. 2019. "Overcoming the Main Barriers of Circular Economy Implementation Through a New Visualization Tool for Circular Business Models." *Sustainability* 11 (23): 6614, 1–33. doi:10.3390/su11236614.

Boiten, V. J., S. Li-Chou Han, and D. Tyler. 2017. "Circular Economy Stakeholder Perspectives: Textile Collection Strategies to Support Material Circularity". http://resyntex.eu/images/downloads/ValrieJBoiten_Textile_collection_ strategies.pdf.

Bouzon, M., K. Govindan, C. M. T. Rodriguez, and L. M. Campos. 2016. "Identification and Analysis of Reverse Logistics Barriers Using Fuzzy Delphi Method and AHP." *Resources, Conservation and Recycling* 108: 182–197. doi:10.1016/j.resconrec.2015.05.021.

Bressanelli, G., M. Perona, and N. Saccani. 2019. "Challenges in Supply Chain Redesign For The Circular Economy: A Literature Review and a Multiple Case Study." *International Journal of Production Research* 57 (23): 7395–7422. doi:10.1080/00207543.2018.1542176.

Brink, J. V. 2018. "Expectations of the Circular Economy in the Fashion Industry" (Master's thesis). Supervisor: Dr. Julian Kirchherr, Universiteit Utrecht.

Brown, P., N. Bocken, and R. Balkenende. 2019. "Why Do Companies Pursue Collaborative Circular Oriented Innovation?" *Sustainability* 11 (635): 1–23. doi:10.3390/su11030635.

Buyukaslan, E., S. Jevsnik, and F. Kalaoglu. 2015. "A Sustainable Approach to Collect Post-Consumer Textile Waste in Developing Countries." *Marmara Fen Bilimleri Dergisi* 27: 107–111.

Camilleri, M. A. 2020. "European Environment Policy for the Circular Economy: Implications for Business and Industry Stakeholders." *Sustainable Development. (in the Early View)*, 1–9. doi:10.1002/sd.2113.

Cao, N., Z. Zhang, K. M. To, and K. P. Ng. 2008. "How Are Supply Chains Coordinated? An Empirical Observation in Textile-Apparel Businesses." *Journal of Fashion Marketing and Management* 12 (3): 384–397. doi:10.1108/13612020810889326.

Charter, M. 2018. "Circular Economy Innovation and Design." In *Designing for the Circular Economy*, edited by Martin Charter. London: Routledge. doi:10.4324/9781315113067

Chen, Y., L. Duan, and W. Zhang. 2020. "Effect of User Involvement in Supply Chain Cloud Innovation: A Game Theoretical Model and Analysis." *Journal of Global Information Management (JGIM)* 28 (1): 23–38. doi:10.4018/JGIM.2020010102.

Cheng, C. C., and H. M. Chou. 2018. "Applying the Concept of Circular Economy – Using the Cultural Difference of European Consumers as an Example." *Proceedings of IEEE International Conference on Applied System Innovation*, 449–452. ISBN 978-1-5386-4342-6.

Clancy, G., M. Fröling, and G. Peters. 2015. "Ecolabels as Drivers of Clothing Design." *Journal of Cleaner Production* 99: 345–353. doi:10.1016/j.jclepro.2015.02.086.

Cong, G., J. Zhang, T. C. Huazhong, and K. Lai. 2008. "A Variable Precision Fuzzy Rough Group Decision-Making Model for IT Offshore Outsourcing Risk Evaluation." *Journal of Global Information Management* 16 (2): 18–34. doi:10.4018/jgim.2008040102.

Coste-Maniere, I., K. Croizet, E. Sette, A. Fanien, H. Guezguez, and H. Lafforgue. 2019. "Circular Economy: A Necessary (R) Evolution." In *Circular Economy in Textiles and Apparel*, edited by M. Senthilkannan, 123–148. Duxford: Woodhead Publishing.

Cramer, J. 2017. "e-Raw Materials Transition in the Amsterdam Metropolitan Area: Added Value for the Economy, Well-Being, and the Environment." *Environment: Science and Policy for Sustainable Development* 59 (3): 14–21. doi:10.1080/00139157.2017.1301167.

Daae, J., L. Chamberlin, and C. Boks. 2019. "Dimensions of Behaviour Change in the Context of Designing for a Circular Economy." *The Design Journal* 21 (4): 521–541. doi:10.1080/14606925.2018.1468003.

Dahlbo, H., K. Aalto, H. Eskelinen, and H. Salmenperä. 2017. "Increasing Textile Circulation-Consequences and Requirements." *Sustainable Production and Consumption* 9: 44–57. doi:10.1016/j.spc.2016.06.005.

Dahlbo, H., V. Poliakova, V. Mylläri, O. Sahimaa, and R. Anderson. 2018. "Recycling Potential of Post-Consumer Plastic Packaging Waste in Finland." *Waste Management* 71: 52–61.

Daňo, F., P. Drábik, and E. Hanuláková. 2020. "Circular Business Models in Textiles and Apparel Sector in Slovakia." *Central European Business Review* 9 (1): 1–19. doi:0.18267/j.cebr.226.

Deineko, L., O. Tsyplitska, and O. Deineko. 2019. "Opportunities and Barriers of the Ukrainian Industry Transition to the Circular Economy." *Environment and Ecology* 10 (1): 79–92. doi:10.21511/ee.10(1).2019.06.

de Jesus, A., and S. Mendonça. 2018. "Lost in Transition? Drivers and Barriers in the Eco-Innovation Road to the Circular Economy." *Ecological Economics Elsevier* 145 (December): 75–89. doi:10.1016/j.ecolecon.2017.08.001.

de Man, R., and H. Friege. 2016. "Circular Economy: European Policy on Shaky Ground." *Waste Management and Research* 34 (2): 93–95. doi:10.1177/0734242X15626015.

Design4Circle. 2019. "Circular Economy in the Textile and Footwear Industry Skills and Competences for a Sector Renewal" (https://design4circle.eu/wp-content/uploads/2019/06/Report%20Design4circle%20-%20IO1%20A3%20ECORES.pdf).

Dieckmann, E., L. Sheldrick, M. Tennant, R. Myers, and C. Cheeseman. 2020. "Analysis of Barriers to Transitioning from a Linear to a Circular Economy for End of Life Materials: A Case Study for Waste Feathers." *Sustainability* 12 (5): 1725. doi:10.3390/su12051725.

Dodick, J., and D. Kauffman. 2017. "A Review of the European Union's Circular Economy Policy." R2∏ Project Report. http://www.r2piproject.eu/wp-content/uploads/2017/04/A- Review -of-the-European-Unions-Circular-Economy-Policy.pdf.
ECAP (The European Clothing Action Plan). 2019. "Circular Textiles Ready to Market, Danish Fashion Institute." http://www.ecap.eu.com/wp-content/uploads/2019/02/Circular-Textiles-Ready-to-market-booklet.pdf.
Elander, M., and H. Ljungkvist. 2016. "Critical Aspects in Design for Fiber-To-Fiber Recycling of Textiles". http://mistrafuturefashion.com/wp-content/uploads/2016/06/MFF-report-2016-1-Critical-aspects.pdf.
Elia, V., M. Grazia Gnoni, and T. Tornese. 2017. "Measuring Circular Economy Strategies Through Index Methods: A Critical Analysis." *Journal of Cleaner Production* 142: 2741–2751. doi:10.1016/j.jclepro.2016.10.196.
Ellen MacArthur, E. 2013. *Towards The Circular Economy, Economic and Business Rationale for an Accelerated Transition* (pp. 21–34). Cowes: Ellen MacArthur Foundation.
Ellen MacArthur Foundation. 2017. "A New Textiles Economy", 3: Redesigning Fashion's Future. http://www.ellenmacarthurfoundation.org/publications.
Esposito, M., T. Tse, and K. Soufani. 2018. "Introducing a Circular Economy: New Thinking with New Managerial and Policy Implications." *California Management Review* 60 (3): 5–19. doi:10.1177/0008125618764691.
European Commission. 2017. "European Circular Economy Stakeholder Platform." http://ec.europa.eu/environment/circulareconomy/index_en.html.
EURATEX. 2017. *Prospering in the Circular Economy: the Case of European Textile & Apparel Manufacturing Industry*. Brussels: EURATEX.
EUROTEX. 2019. "Policy Brief-Prospering in the Circular Economy: The Case of European Textile and Apparel Manufacturing Industry", https://euratex.eu/wp-content/uploads/2019/01/EURATEX_CE_policy_brief_LR.pdf.
Farooque, M., A. Zhang, M. Thürer, T. Qu, and D. Huisingh. 2019. "Circular Supply Chain Management: A Definition and Structured Literature Review." *Journal of Cleaner Production* 228: 882–900. doi:10.1016/j.jclepro.2019.04.303.
Fekri, R., A. Aliahmadi, and M. Fathian. 2009. "Identifying the Cause and Effect Factors of Agile NPD Process With Fuzzy DEMATEL Method: The Case of Iranian Companies." *Journal of Intelligent Manufacturing* 20 (6): 637.
Filho, W. L., D. Ellams, S. Han, D. Tyler, V. Boiten, A. Paco, H. Moora, and A. L. Balogun. 2019. "A Review of the Socio-Economic Advantages of Textile Recycling." *Journal of Cleaner Production* 218: 10–20. doi:10.1016/j.jclepro.2019.01.210.
Fischer, A., and S. Pascucci. 2017. "Institutional Incentives in Circular Economy Transition: The Case of Material Use in the Dutch Textile Industry." *Journal of Cleaner Production* 155 (2): 17–32. doi:10.1016/j.jclepro.2016.12.038.
Fletcher, K. 2014. *Sustainable Fashion and Textiles: Design Journeys*. 2nd ed. London: Routledge.
Fontela, E., and A. Gabus. 1976. "The DEMATEL Observer", DEMATEL 1976 report. Switzerland Geneva: Battelle Geneva Research Center. master_Aaltonen_Silla_2020.pdf.
Fontell, P., and P. Heikkilä. 2017. "Model of Circular Business Ecosystem for Textiles", *VTT Technology* 313. www.vtt.fi/inf/pdf/technology/2017/T313.pdf.
Franco, M. 2017. "Circular Economy at the Micro Level: A Dynamic View of Incumbents' Struggles And Challenges In The Textile Industry." *Journal of Cleaner Production* 168 (1): 833–845. doi:10.1016/j.jclepro.2017.09.056.
Gabus, A., and E. Fontela. 1972. *World Problems, An Invitation To Further Thought Within The Framework of DEMATEL*. Geneva: Battelle Geneva Research Centre.
Gabus, A., and E. Fontela. 1973. "Perceptions of the World Problematique: Communication Procedure, Communicating with Those Bearing Collective Responsibility (DEMATEL report no. 1)". Switzerland Geneva: Battelle Geneva Research Centre.
Geng, Y., J. Fu, J. Sarkis, and B. Xue. 2012. "Towards a National Circular Economy Indicator System in China: An Evaluation and Critical Analysis." *Journal of Cleaner Production* 23: 216–224. doi:10.1016/j.jclepro.2011.07.005.
Genovese, A., A. A. Acquaye, A. Figueroa, and S. C. Lenny Koh. 2017. "Sustainable Supply Chain Management and the Transition Towards a Circular Economy: Evidence and Some Applications." *Omega* 66 (January): 344–357. doi:10.1016/j.omega.2015.05.015.
Govindan, K., and M. Hasanagic. 2018. "A Systematic Review on Drivers, Barriers, and Practices Towards Circular Economy: A Supply Chain Perspective." *International Journal of Production Research* Taylor and Francis 56 (1–2): 278–311. doi:10.1080/00207543.2017.1402141.
Gupta, S., H. Chen, B. T. Hazen, S. Kaur, and E. D. S. Gonzalez. 2019. "Circular Economy and Big Data Analytics: A Stakeholder Perspective." *Technological Forecasting and Social Change* 144: 466–474. doi:10.1016/j.techfore.2018.06.030.
Gupta, K., R. F., Laubscher, J. P., Davim, and N. K. Jain. 2016. "Recent Developments in Sustainable Manufacturing of Gears: A Review". *Journal of Cleaner Production* 112 (4): 3320–330. doi:10.1016/j.jclepro.2015.09.133.
Hart, J., K. Adams, J. Giesekam, D. D. Tingley, and F. Pomponi. 2019. "Barriers and Drivers in a Circular Economy: The Case of the Built Environment." *Procedia CIRP* 80: 619–624.
Hawley, J. M. 2014. "Textile Recycling". *Handbook of Recycling: State-of-the-art for Practitioners, Analysts, and Scientists. Newnes*, edited by E. Worrell, and M. Reuter, 211–217. Oxford: Elsevier.

Hazen, B. T., D. A. Mollenkopf, and Y. Wang. 2017. "Remanufacturing for the Circular Economy: An Examination of Consumer Switching Behavior." *Business Strategy and the Environment* 26 (4): 451–464. doi:10.1002/bse.1929.

Hendiani, S., H. Liao, and C. J. C. Jabbour. 2020. "A New Sustainability Indicator for Supply Chains: Theoretical and Practical Contribution Towards Sustainable Operations." *International Journal of Logistics Research and Applications*, 1–26. doi:10.1080/13675567.2020.1761308.

Herrero Rodríguez, P. 2017. "Circular Economy: Application in the Textile Industry." In *Degree in Finance and Accounting, Supervised*, edited by María Ángeles Fernández Izquierdo. Valencia: Universitat JaumeI, Castelló de la Plana.

Ilić, M., and M. Nikolić. 2016. "Drivers for Development of Circular Economy – A Case Study of Serbia." *Habitat International* 56: 191–200. doi:10.1016/j.habitatint.2016.06.003.

Istanbul Textile and Raw Materials Exporters Association (ITRMEA). 2019. https://www.etextilemagazine.com/en/exports-break-record-of-all-time-in-october.html.

Jabbour, C. J. C., S. Seuring, A. B. L. de Sousa Jabbour, D. Jugend, P. D. C. Fiorini, H. Latan, and W. C. Izeppi. 2020. "Stakeholders, Innovative Business Models For the Circular Economy and Sustainable Performance of Firms in an Emerging Economy Facing Institutional Voids." *Journal of Environmental Management* 264: 110416. doi:10.1016/j.jenvman.2020.110416.

Jakhar, S. K., S. K. Mangla, S. Luthra, and S. Kusi-Sarpong. 2018. "When Stakeholder Pressure Drives the Circular Economy: Measuring the Mediating Role of Innovation Capabilities." *Management Decision* 57 (4): 904–920. doi:10.1108/MD-09-2018-0990.

Jia, F., S. Yin, L. Chen, and X. Chen. 2020. "The Circular Economy in the Textile and Apparel Industry: A Systematic Literature Review." *Journal of Cleaner Production* 259: 1–20. doi:10.1016/j.jclepro.2020.120728.

Jugend, D., P. D. Camargo Fiorini, M. A. P. Pinheiro, H. M. R. da Silva, and B. M. R. Pais Seles. 2020. "Building Circular Products in an Emerging Economy: An Initial Exploration Regarding Practices, Drivers and Barriers: Case Studies of New Product Development from Medium and Large Brazilian Companies." *Johnson Matthey Technology Review* 64 (1): 59–68. doi:10.1595/205651320X15706349546439.

Karlsson, I., J. Rootzén, and F. Johnsson. 2020. "Reaching Net-Zero Carbon Emissions in Construction Supply Chains – Analysis of a Swedish Road Construction Project." *Renewable and Sustainable Energy Reviews* 120 (March): 1–33. doi:10.1016/j.rser.2019.109651.

Kaur, J., R. Sidhu, A. Awasthi, S. Chauhan, and S. Goyal. 2018. "A DEMATEL Based Approach for Investigating Barriers in Green Supply Chain Management In Canadian Manufacturing Firms." *International Journal of Production Research* 56 (1-2): 312–332.

Khandelwal, C., and M. K. Barua. 2020. "Prioritizing Circular Supply Chain Management Barriers Using Fuzzy AHP: Case of the Indian Plastic Industry." *Global Business Review*, 0972150920948818.

Kirchherr, J., M. Hekkert, R. Bour, A. Huijbrechtse-Truijens, E. Kostense-Smit, and J. Muller. 2017. "Breaking the Barriers to the Circular Economy." Deloitte and Utrecht University Research Report. https://circulareconomy.europa.eu/platform/sites/default/files/171106_white_paper_breaking_the_barriers_to_the_circular_economy_white_paper_vweb-14021.pdf.

Kirchherr, J., L. Piscicelli, R. Bour, E. Kostense-Smit, J. Muller, A. Huibrechtse-Truijens, and M. Hekkert. 2018. "Barriers to the Circular Economy: Evidence from the European Union (EU)." *Ecological Economics* 150: 264–272. doi:10.1016/j.ecolecon.2018.04.028.

Koszewska, M. 2018. "Circular Economy – Challenges for the Textile and Clothing Industry." *AUTEX Research Journal* 18 (4): 337–347. doi:10.1515/aut-2018-0023.

Kumar, P. S., and C. F. Carolin. 2019. "Future for Circular Economy." In *Manufacturing Circular Economy in Textiles and Apparel Processing and Design*, edited by Subramanian Senthilkannan Muthu, 208–217. The Textile Institute Book Series. Duxford: Woodhead Publishing.

Kumar, V., I. Sezersan, J. A. Garza-Reyes, E. D. R. S. Gonzalez, and M. A. AL-Shboul. 2019. "Circular Economy in the Manufacturing Sector: Benefits, Opportunities and Barriers." *Management Decision* 57 (4): 1067–1086. doi:10.1108/MD-09-2018-1070.

Kumar, P. S., and S. Suganya. 2019. "Systems and Models for Circular Economy." In *Manufacturing Circular Economy in Textiles and Apparel Processing and Design*, edited by Subramanian Senthilkannan Muthu, 169–181. The Textile Institute Book Series. Duxford: Woodhead Publishing.

Kurkela, E. 2020. "Drivers and Challenges of Circular Business Models: Comparative Case Study In Textile Industry." Supervisor: Anni Rajala, School of Management Master`s thesis in Economics and Business Administration Strategic Business Development, 78.

Li, R. J. 1999. "Fuzzy Method in Group Decision Making." *Computers & Mathematics with Applications* 38 (1): 91–101.

Li, J., and K. Yu. 2009. "A Study on Legislative and Policy Tools for Promoting the Circular Economic Model for Waste Management in China." *Journal of Material Cycles and Waste Management* 13 (2): 103–112. doi:10.1007/s10163-011-0010-4.

Li, J., and K. Yu. 2011. "A Study on Legislative and Policy Tools for Promoting the Circular Economic Model for Waste Management in China." *Journal of Material Cycles and Waste Management* 13 (2): 103–112.

Lin, C. J., and W. W. Wu. 2008. "A Causal Analytical Method for Group Decision-Making under Fuzzy Environment." *Expert Systems with Applications* 34 (1): 205–213. doi:10.1016/j.eswa.2006.08.012.
Luthra, S., S. K. Mangla, and G. Yadav. 2019. "An Analysis of Causal Relationships Among Challenges Impeding Redistributed Manufacturing in Emerging Economies." *Journal of Cleaner Production* 225: 949–962. doi:10.1016/j.jclepro.2019.04.011.
Maitre-Ekern, E., and C. Dalhammar. 2016. "Regulating Planned Obsolescence: A Review of Legal Approaches to Increase Product Durability and Reparability in Europe." *Review of European, Comparative and International Environmental Law* 25 (3): 378–394. doi:10.1111/reel.12182.
Malek, J., and T. N. Desai. 2019. "Interpretive Structural Modelling-Based Analysis of Sustainable Manufacturing Enablers." *Journal of Cleaner Production* 238: 117996. doi:10.1016/j.jclepro.2019.117996.
Malik, A., M. Lenzen, R. N. Ely, and E. Dietzenbacher. 2014. "Simulating the Impact of New Industries on the Economy: The Case of Biorefining in Australia." *Ecological Economics* 107: 84–93. doi:10.1016/j.ecolecon.2014.07.022.
Mangla, S. K., K. Govindan, and S. Luthra. 2017. "Prioritizing the Barriers to Achieve Sustainable Consumption and Production Trends in Supply Chains Using Fuzzy Analytical Hierarchy Process." *Journal of Cleaner Production* 151: 509–525. doi:10.1016/j.jclepro.2017.02.099.
Mangla, S. K., S. Luthra, N. Mishra, A. Singh, N. P. Rana, M. Dora, and Y. Dwivedi. 2018. "Barriers To Effective Circular Supply Chain Management In A Developing Country Context." *Production Planning and Control* 29 (6): 551–569. doi:10.1080/09537287.2018.1449265.
Manickam, P., and G. Duraisamy. 2019. "3Rs and Circular Economy." In *Manufacturing Circular Economy in Textiles and Apparel Processing and Design*, edited by Subramanian Senthilkannan Muthu, 77–93. The Textile Institute Book Series. Duxford: Woodhead Publishing.
Masi, D., V. Kumar, J. Garza-Reyes, and J. Godsell. 2018. "Towards a More Circular Economy: Exploring the Awareness, Practices, and Barriers from a Focal Firm Perspective." *Production Planning and Control* 29 (6): 539–550. doi:10.1080/09537287.2018.1449246.
Mazzanti, M., and A. Montini. 2014. "Waste Management Beyond The Italian North–South Divide: Spatial Analyses of Geographical, Economic and Institutional Dimensions." In *Handbook of Waste Management (Chapter 10)*, edited by Thomas C. Kinnaman and Kenji Takeuchi, 256–284. Paris: Edward Elgar.
Moktadir, M. A., T. Rahman, M. H. Rahman, S. M. Ali, and S. K. Paul. 2020. "Drivers to Sustainable Manufacturing Practices and Circular Economy: A Perspective of Leather Industries in Bangladesh." *Journal of Cleaner Production* 174: 1366–1380. doi:10.1016/j.jclepro.2017.11.063.
Mont, O., A. Plepys, K. Whalen, and J. L. K. Nußholz. 2017. "Business Model Innovation for a Circular Economy: Drivers and Barriers for The Swedish Industry – The Voice of REES companies." *Mistra REES*. http://lup.lub.lu.se/search/ws/files/33914256/MISTRA_REES_Drivers_and_Barriers_Lund.pdf.
Morone, P., and R. Navia. 2016. "New Consumption and Production Models for a Circular Economy." *Waste Management and Research* 34 (6): 489–490. doi:10.1177/0734242X16652281.
Mukherjee, S. 2015. "Environmental And Social Impact of Fashion: Towards an Eco-Friendly, Ethical Fashion." *International Journal of Interdisciplinary and Multidisciplinary Studies* 2 (3): 22–35.
Muradin, M., and Z. Foltynowicz. 2019. "The Circular Economy in the Standardized Management System." *Amfiteatru Economic* 21 (13): 871–883. doi:10.24818/EA/2019/S13/871.
Niinimäki, K., and L. Hassi. 2011. "Emerging Design Strategies in Sustainable Production and Consumption of Textiles and Clothing." *Journal of Cleaner Production* 19 (16): 1876–1883. doi:10.1016/j.jclepro.2011.04.020.
Opricovic, S., and G. H. Tzeng. 2004. "Compromise Solution by MCDM Methods: A Comparative Analysis of VIKOR and TOPSIS." *European Journal of Operational Research* 156 (2): 445–455. doi:10.1016/S0377-2217(03)00020-1.
Ozdamar Ertekin, Z., and D. Atik. 2020. "Institutional Constituents of Change for a Sustainable Fashion System." *Journal of Macromarketing* 40 (3): 362–379. doi:10.1177/0276146720932274.
Paletta, A., W. Leal Filho, A. L. Balogun, E. Foschi, and A. Bonoli. 2019. "Barriers and Challenges to Plastics Valorisation in the Context of a Circular Economy: Case Studies from Italy." *Journal of Cleaner Production* 241: 118149. doi:10.1016/j.jclepro.2019.118149.
Pandit, P., G. T. Nadathur, and S. Jose. 2019. "Upcycled And Low-Cost Sustainable Business For Value-Added Textiles and Fashion." In *Circular Economy in Textiles and Apparel: Processing, Manufacturing and Design*, edited by Subramanian Senthilkannan Muthu, 95–122. The Textile Institute Book Series. Duxford: Woodhead Publishing.
Parajuly, K. 2017. "Circular Economy in E-waste Management: Resource Recovery and Design for End-of-Life." Institute of Chemical Engineering, Biotechnology and Environmental Technology, SDU Life Cycle Engineering, Ph.D. Thesis.
Pasqualotto, I. 2015. "The Sustainable Business Perspectives: Circular Economy and Textile Recycling Market Opportunities." Master's Thesis in Business Administration, Finance and Control, Universita.

Patel, A. B., and T. N. Desai. 2019. "A Systematic Review and Meta-Analysis of Recent Developments in Sustainable Supply Chain Management." *International Journal of Logistics Research and Applications* 22 (4): 349–370. doi:10.1080/13675567.2018.1534946.

Pathak, R., and A. Endayilalu. 2019. "Circular Economy: A Perspective of Ethiopian Textile Sector." *IJCIRAS* 1 (1): 101–109. http://ijciras.com/PublishedPaper/IJCIRAS1192.pdf.

Pheifer, A. G. 2017. "Barriers and Enablers to Circular Business Models." (April): 1–26. https://www.circulairondernemen.nl/uploads/4f4995c266e00bee8fdb8fb34fbc5c15.pdf.

Ræbild, U., and A. L. Bang. 2017. "Rethinking the Fashion Collection as a Design Strategic Tool in a Circular Economy." *The Design Journal* 20 (1): 589–599. doi:10.1080/14606925.2017.1353007.

Rathinamoorthy, R. 2019. "Circular Fashion in Circular Economy." In *Manufacturing Circular Economy in Textiles and Apparel Processing and Design*, edited by Subramanian Senthilkannan Muthu, 13–48. the Textile Institute Book Series. Duxford: Woodhead Publishing.

Rizos, V., A. Behrens, T. Kafyeke, M. Hirschnitz-Garbers, and A. Ioannou. 2015. "The Circular Economy: Barriers and Opportunities for SMEs". CEPS Working Documents. No. 412. http://aei.pitt.edu/67297/1/WD412_GreenEconet_SMEs_Circular_Economy.pdf.

Rizos, V., A. Behrens, W. Van der Gaast, E. Hofman, A. Ioannou, T. Kafyeke, A. Flamos, et al. 2016. "Implementation of Circular Economy Business Models By Small and Medium-Sized Enterprises (SMES): Barriers and Enablers." *Sustainability* 8 (1212): 1–18. doi:10.3390/su8111212.

Roosendaal, J. 2018. "Breaking Barriers to Circular Economy in the Dutch Textiles Industry", Master Thesis in Sustainable Business and Innovation. Utrecht University.

Rossi, E., A. C. Bertassini, C. dos Santos Ferreira, W. A. N. do Amaral, and A. R. Ometto. 2020. "Circular Economy Indicators for Organizations Considering Sustainability and Business Models: Plastic, Textile and Electro-Electronic Cases." *Journal of Cleaner Production* 247: 1–16. doi:10.1016/j.jclepro.2019.119137.

Sabaghi, M., C. Mascle, and P. Baptiste. 2016. "Evaluation of Products at Design Phase for an Efficient Disassembly at End-of-Life." *Journal of Cleaner Production* 116 (March): 177–186. doi:10.1016/j.jclepro.2016.01.007.

Sabanoglu, T. 2019. "Textiles and Clothing Industry in Turkey – Statistics and Facts." https://www.statista.com/topics/4844/textiles-and-clothing-industry-in-turkey/.

Sandvik, I. 2017. *Applying Circular Economy To The Fashion Industry In Scandinavia Through Textile-to-Textile Recycling*. Monash: Master of International Development Practice, Monash University.

Sandvik, I. M., and W. Stubbs. 2019. "Circular Fashion Supply Chain through Textile-to-Textile Recycling." *Journal of Fashion Marketing and Management* 23 (3): 366–381. doi:10.1108/JFMM-04-2018-0058.

Schroeder, P., K. Anggraeni, and U. Weber. 2018. "The Relevance of Circular Economy Practices to the Sustainable Development Goals: Circular Economy and SDGs." *Journal of Industrial Ecology* 23 (1): 77–95. doi:10.1111/jiec.12732.

Smith, P., J. Baille, and L. S. McHattie. 2017. "Sustainable Design Futures: An Open Design Vision for the Circular Economy in Fashion and Textiles." *The Design Journal* 20 (1): 1938–1947. doi:10.1080/14606925.2017.1352712.

Snoek, S. 2017. "Circular Economy in the Textile Industry – Transition Theory in Start-Ups in the Textile Industry", Master Thesis in Climate Studies Environmental Policy, Wageningen UR.

Song, M., and S. Wang. 2017. "Participation in Global Value Chain and Green Technology Progress: Evidence from Big Data of Chinese Enterprises." *Environmental Science and Pollution Research* 24 (2): 1648–1661.

Song, M., Q. Xie, S. Wang, and H. Zhang. 2020. "Could Environmental Regulation and Randd Tax Incentives Affect Green Product Innovation?" *Journal of Cleaner Production* 258: 120849. doi:10.1016/j.jclepro.2020.120849.

Spring, M., and L. Araujo. 2017. "Product Biographies in Servitization and the Circular Economy." *Industrial Marketing Management* 60: 126–137. doi:10.1016/j.indmarman.2016.07.001.

Su, B., A. Heshmati, y. Geng, and X. Yu. 2013. "A Review of the Circular Economy in China: Moving from Rhetoric to Implementation." *Journal of Cleaner Production* 42: 215–227. doi:10.1016/j.jclepro.2012.11.020.

Tatoglu, E., E. Bayraktar, I. Golgeci, S. L. Koh, M. Demirbag, and S. Zaim. 2016. "How Do Supply Chain Management and Information Systems Practices Influence Operational Performance? Evidence from Emerging Country SMES." *International Journal of Logistics Research and Applications* 19 (3): 181–199. doi:10.1080/13675567.2015.1065802.

Textile Focus. 2019. "Turkish Textile Sector Is Getting Strong in Global Market." http://textilefocus.com/turkish-textile-sector-getting-strong-global-market/.

Tseng, M. L., H. M. Ha, M. K. Lim, K. J. Wu, and M. Iranmanesh. 2020. "Sustainable Supply Chain Management in Stakeholders: Supporting from Sustainable Supply And Process Management in The Healthcare Industry in Vietnam." *International Journal of Logistics Research and Applications*, doi:10.1080/13675567.2020.1749577.

Tseng, M. L., and Y. H. Lin. 2009. "Application of Fuzzy DEMATEL To Develop A Cause And Effect Model of Municipal Solid Waste Management in Metro Manila." *Environmental Monitoring And Assessment* 158 (1–4): 519. doi:10.1007/s10661-008-0601-2.

Tura, N., J. Hanski, T. Ahola, M. Stahle, S. Piiparinen, and P. Valkokari. 2019. "Unlocking Circular Business: A Framework of Barriers and Drivers." *Journal of Cleaner Production* 212: 90–98. doi:10.1016/j.jclepro.2018.11.202.

van der Velden, N. M., M. K. Patel, and J. G. Vogtländer. 2014. "LCA Benchmarking Study on Textiles Made of Cotton, Polyester, Nylon, Acryl or Elastane." *International Journal of Life Cycle Assessment* 19: 331–356. doi:10.1007/s11367-013-0626-9.

Vermeulen, W. J. 2015. "Self-Governance for Sustainable Global Supply Chains: Can It Deliver The Impacts Needed?" *Business Strategy and the Environment* 24 (2): 73–85. doi:10.1002/bse.1804.

Wastling, T., F. Charnley, and M. Moreno. 2018. "Design For Circular Behaviour: Considering Users In A Circular Economy." *Sustainability* 10 (6): 1743. doi:10.3390/su10061743.

Werning, J. P., and S. Spinler. 2020. "Transition to Circular Economy on Firm Level: Barrier Identification and Prioritization Along the Value Chain." *Journal of Cleaner Production* 245: 118609. doi:10.1016/j.jclepro.2019.118609.

Whicher, A., C. Harris, K. Beverley, & P. Swiatek. 2018. "Design for Circular Economy: Developing an Action Plan for Scotland." *Journal of Cleaner Production* 172: 3237–3248. doi:10.1016/j.jclepro.2017.11.009.

Wilson, L. 2015. "The Sustainable Future of the Scottish Textiles Sector: Challenges and Opportunities of Introducing a Circular Economy Model." *Textiles and Clothing Sustainability* 1 (1): 1–9. doi:10.1186/s40689-015-0005-y.

Wu, W. W., and Y. T. Lee. 2007. "Developing Global Managers' Competencies Using the Fuzzy DEMATEL Method." *Expert Systems with Applications* 32 (2): 499–507. doi:10.1016/j.eswa.2005.12.005.

Wu, C., and S. Tsai. 2018. "Using DEMATEL-Based ANP Model to Measure the Successful Factors of E-Commerce." *Journal of Global Information Management (JGIM)* 26 (1): 120–135. doi:10.4018/JGIM.2018010107.

Yadav, G., S. Luthra, S. K. Jakhar, S. K. Mangla, and D. P. Rai. 2020. "A Framework to Overcome Sustainable Supply Chain Challenges Through Solution Measures of Industry 4.0 and Circular Economy: An Automotive Case." *Journal of Cleaner Production* 254: 120112. doi:10.1016/j.jclepro.2020.120112.

Yager, R. R., and D. P. Filev. 1994. "Generation of Fuzzy Rules by Mountain Clustering." *Journal of Intelligent and Fuzzy Systems* 2 (3): 209–219.

Yang, Y., and R. John. 2003. "Grey Systems and Interval Valued Fuzzy Sets". In *EUSFLAT Conference*, 193–197.

Yoleri, E. 2020. "5.5% Export Loss in 2019 for the Turkish Textile Industry." https://www.textilegence.com/en/export-loss-in-2019-for-the-turkish-textile-industry/.

Zhou, X., M. Song, and L. Cui. 2020. "Driving Force for China's Economic Development under Industry 4.0 and Circular Economy: Technological Innovation or Structural Change?" *Journal of Cleaner Production* 263: 122680. doi:10.1016/j.jclepro.2020.122680.