Report On

Identifying Critical Barriers to Circular Supply Chain Management in the Leather Industry of Bangladesh Using Fuzzy DEMATEL Approach

By

Saima Ahmed Nishu
18104289

A thesis report submitted to the BRAC Business School

in partial fulfillment of the requirements for the degree of

Bachelors of Business Administration

BRAC Business School

BRAC University
June, 2022

Declaration

It is hereby declared that

1. The thesis report submitted is my own original work while completing degree at BRAC University.

2. The report does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.

3. The report does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.

4. I have acknowledged all main sources of help.

Student's Full Name & Signature:

Saima Ahmed Nishu

18104289

Supervisor's Full Name & Signature:

____

Dr. Md Shamimul Islam

Assistant Professor, BRAC Business School

BRAC University

Acknowledgement

I'd like to express my gratitude to everyone who helped me finish this thesis paper. I'd want to express my heartfelt gratitude to Dr. Md Shamimul Islam, Assistant Professor, BRAC Business School, BRAC University, for allowing me to do research and providing me with vital support during this process. His dynamism, vision, genuineness, and motivation have left an indelible impression on me. He has taught them how to write each component of the research paper and how to explain the results as simply as possible. It was a great honor and joy to work and study under his direction. I'd also like to express my gratitude for his friendship, understanding, and excellent sense of humor during the planning process.

Furthermore, I would want to express my gratitude to the respected respondents Dr. Md. Abdul Mottalib, Mr. Abdur Rahman, Mr. Alamgir Hossain, Mrs. Sultana Chowdhury, Mr. Moktadir Rahman for taking time out of their busy schedules to fill out my survey and assist me in completing the necessary assignment. I owe the supervisor a huge debt of gratitude for taking me through the entire report from start to finish. While working under his supervision, I was able to grasp the technique and develop my research skills.

Abstract

The Bangladeshi leather industry is under enormous pressure due to its negative effects on the environment and endangering people's lives. According to some studies, implementing CSCM can assist the industries of both developed and developing countries in overcoming these challenges. Although previous research has identified the barriers to implementing CSCM in the leather industry, this study focuses on the most influential barriers to CSCM practices. As a result, this study uses a cause-and-effect diagram to identify barriers in order to produce the best possible result for future reference. The study identified 32 different barriers to CSCM from different literature reviews, but only 17 of them were chosen with the help of industry experts and scholars. Later the 17 barriers were then evaluated using the DEMATEL approach to determine the interrelationships between them. Six barriers were in the cause group and five were in the consequence group in the diagram. The cost of hazardous product disposal is the main factor, whereas other methods may be more advantageous. The effect factor is strongly influenced by the cause factor. This study, on the other hand, attempts to assist the leather sector by assisting managers in identifying the most significant impediments to CSCM implementation so that they might attempt to eliminate such roadblocks. The study was conducted with a small number of industry experts and scholars, and there were initially very few responses. Furthermore, there have been very few empirical studies in this field, which is a hindrance for researchers.

Keywords: Circular Supply Chain Management, DEMATEL, Barriers, Leather Industry, Bangladesh.

Table of Contents

1. Introduction

The term "sustainability" has become a popular trend in many nations throughout the world; this trend is important for the reduction of pollution and the creation of a toxic-free environment for the benefit of the people who live there. (2016, Rebecca). Many countries in Europe, Africa, and Asia are adopting a variety of sustainability policies while considering the long-term implications. Among them circular supply chain management has gained a lot of popularity for its sustainable practices. The process represents a production system where resources are reused, remanufactured and recycled by an infinite loop (Mangla et al., 2018) CSCM helps to recycle resources throughout the product life cycle by optimizing resource consumption. (Genovese et al. 2017) (Mangla et al., 2018) Manufacturing companies, in particular, are attempting to integrate circular supply chain models into their operations in order to lengthen product life cycles, build economic sustainability through customer predilection, preferences for secondary goods and products, and manage waste (Mangla et al., 2018). The reason for incorporating CSCM is that it can assist firms to reduce material waste, reduce negative environmental impacts, and ensure that products follow a circular model of reuse, recycle, and regenerate. (Nasir et al. 2017; Genovese et al. 2017) (2018, Mangla et al.) Furthermore, CSCM is seen as a viable solution to issues such as pollution, resource scarcity, and unattainable production and consumption habits. (Genovese et al. 2017; Nasir et al. 2017) (Mangla et al., 2018) Experts suggests that the countries that have higher GDP growth rate like Libya, Bangladesh, Ethiopia to start implementing CSCM because there are ample opportunities in such countries to focus on CSCM research for their economies, social and environmental growth. (Lahane, Kant, & Shankar, 2020)

In developing countries leather industries are one of the major contributors to the economy (Moktadir, Ali, Rajesh, & Paul, 2018) Raw hides and skins are the most often used raw materials in the leather business, and they are readily available in Bangladesh's leather industry. Moktadir, Ali, Rajesh, and Paul (Moktadir, Ali, Rajesh, and Paul, 2018) Furthermore, the sophisticated chemical processes that turn raw hides and skins into finished leather pollute the environment tremendously, making it one of Bangladesh's most hazardous yet profitable industries. (Moktadir, Ali, Rajesh, & Paul, 2018) For more than 60 years, Bangladesh's leather industry has been at the heart of the city of Hazaribagh. D. Sun (n.d.). Since it is a hazard to the environment, leather businesses have been shifted from developed to developing countries (Karn and Harada, 2001) (2018) (Islam, Tseng, Karia, and Lee) The Bangladeshi government chose Hemayetpur as the new location in 2017. The tannery units in the midst of the city in Hazaribagh were responsible for river and air pollution in the capital. Sun, D. (n.d.). The heart of the capital Buriganga river is on the verge of death due to the pollution caused by tanneries. Shifting the tannery to Hemayetpur was not effective because the tanneries are still polluting the Dhaleshawari river. (Sarkar, 2022). In this context, the industry must urgently address the difficulties that are generating environmental problems (Islam, Tseng, Karia, & Lee, 2018), and the impediments to implementing CSCM must be overcome, since this industry plays a critical role in earning a significant amount of foreign currency through exports (EPB, 2016) 2018 (Islam, Tseng, Karia, & Lee)

The government is also putting a lot of pressure on the business because of environmental problems (Arias-Barreiro et al., 2010; Institute, 2013) 2018 (Islam, Tseng, Karia, & Lee) Bangladesh's leather sector will be able to reduce waste and negative environmental consequences in the supply chain by adopting a circular model of product, material, and waste flow if CSCM is enabled. (Genovese et al., 2017; Nasir et al., 2017). Thus, CSCM adoption can increase environmental performance and make the industry more sustainable. (Islam, Tseng, Karia, & Lee, 2018) Practitioners have found it challenging to monitor and execute CSCM in the leather sector due to a lack of adequate CSCM barriers being identified. Prior to such an assessment, industry professionals and scholars must identify potential hurdles, and then take the required actions to remove those barriers. Several researchers have discussed implementing CSCM in manufacturing industries and used various models to justify their ground. For instance (Moktadir, Ali, Rajesh, & Paul, 2018) identifies barriers and find interaction among identified barriers. (Jaeger & Upadhyay, 2020) identifies the barriers for overall manufacturing industries. (Govindan & Hasanagic, 2018)

A circular economy framework was investigated, as well as the primary motivations, practices, and restrictions. (Moktadir, Rahman, Ali, & Paul, 2018) analyzed the drivers to sustainable manufacturing practices in Bangladesh’s perspective with the help of experts and using GTMA module and attribute-based rating scale. Given the significance of CSCM implementation, this paper investigated the barriers to CSCM implementation in Bangladesh's leather sector by assessing eight categories, such as governmental, economic, and technological, and determining which one has the greatest impact on the barriers. The analysis will be done using Fuzzy DEMATEL analysis process followed by a survey. The survey will be done by the industry experts and scholars who have been working or have prior knowledge in this field.

Bangladesh’s leather industry is under intense international pressure to adopt CSCM in the manufacturing sector (Moktadir, Ali, Rajesh, & Paul, 2018). Because the leather industry in Bangladesh is ripe with opportunities and growth, it’s critical to identify the potential roadblocks to its development. Keeping the aforementioned issues in mind the study will address the following research questions.

- What are the potential barriers to CSCM in the leather industry context?
- What is the appropriate method to find the critical barriers?
- What are the critical barriers to CSCM?

The contributions of this study are divided into sections, firstly the study has added values to existing knowledge from its measure for evaluating. Secondly, it used Fuzzy DEMATEL method which is widely known for its correct analysis and its assessment is perfect for leather industry. There are few studies done on this field using DEMATEL thus this study contributes to other many aspects. A scientific investigation on CSCM from a Bangladeshi perspective is not so often done as a result, the current research contributed to the existing of knowledge from the perspective of a developing country. The study also contributes to managers understanding by pointing out the managerial implications. It gives an overall idea of the barriers to CSCM in the leather industry to help managers come up with strategies to overcome these barriers.

The remaining paper is divided into sections where in section 2 under literature review will show analysis of different aspects of circular economy found from the survey. Section 3 will focus on research design and methodology. Section 4 will present the analysis using Fuzzy DEMATEL method. Section 5 will present the managerial implications and discussion and finally section 6 represents the suggestions or recommendation with a concluding paragraph.

2. Literature review

This part of the paper gives an idea of circular supply chain management and shows the barriers associated with its implementation in leather industry of Bangladesh by pointing out the most influential barriers among all the eight categories.

2.1 Circular Economy Supply Chain Management

The MacArthur Foundation's most well-known definition of circular economy is an industrial economy that is restorative or regenerative by design Similarly, the circular economy was characterized by Geng and Doberstein as the realization of a closed loop material flow throughout the entire ecosystem. According to (Bastein et al.2013), at a circular economy, value creation can rise in each systemic link while value destruction falls overall. Even while CE thinking is not a new concept, it has recently gained traction in the business world. Because it improves social benefits while carefully avoiding negative environmental impacts, the circular economy is garnering a lot of attention. (Korhonen et al., 2018; Agyemang et al., 2019) (Karuppiah et al., 2021).

Following a thorough investigation into the circular economy, it can be concluded that CE methods resources are preserved in a closed loop, which means that when a product reaches the end of its life cycle, it is reused (Lonca et al., 2020). (Karuppiah et al., 2021). According to Schroeder et al. (2019), SDG goals can be achieved by practicing CE and the goals include safe water and improved sanitation, infrastructure development and sustainable consumption and production (Karuppiah et al., 2021) (Schroeder et al., 2021). Many industries, including food and chemical products leather fabric industry construction materials, car, and electronics, all benefit from the circular economy. (Ehrenfeld & Gertler, 1997) (Genovese et al., 2017) (Li, Bao, Xiu, Zhang, & Xu, 2010); (Ma, Hu, Chen, & Zhu, 2015) (Hu et al., 2011) (Biehl, Prater, & Realff, 2007). Reusing and recycling items will also aid the environment and the economy because the product's lifespan will be extended and many more opportunities will be replaced. (De Angelis, Howard, and Miemczyk, 2018)

The circular supply chain focuses on end-of-life product management for reuse, repair, re-assembly, remanufacturing, recycling, and trash disposal. (Govindan & Soleimani, 2017) (Govindan et al., 2015). By reducing material flow in both manufacturing and consuming processes, sustainable supply chain management attempts to reduce pollution and waste production throughout the supply chain (Dong et. al 2016) (Sarkis et. al 2011) (Genovese, et al. 2017) As a result of recent achievements in the field of sustainability, businesses are now integrating economic, environmental, and social considerations into their supply chains (Morali and Searcy, 2013).

The circular economy supply chain aims to reduce the need for advanced materials by repurposing current ones, according to (Kok, et al 2013) They also suggested that it can finish its practice by thinking about how a product might work in a closed loop (Kok, et al 2013) Customers return abandoned products to the original maker for reuse or value recovery in closed-loop supply chains. (French and LaForge, 2006) (Diao, 2021). According to Bastein et al. (2013), business plans related to the quality economy (Stahel, 2006) based on providing direct exposure rather than trying to sell products that fulfill customers' needs (De Angelis, Howard, & Miemczyk, 2018) have emerged in some sectors (e.g. mobility, building supplies, lighting, aviation), with the ability to expand even further as exchange of (De Angelis, Howard, & Miemczyk, 2018) information types of technology advances and consumers (Lacy and Rutqvist 2015)

2.2 CSCM implementation: Barriers

Table 1 represents the challenges to CSCM implementation in Bangladesh's leather sector. The barriers are divided into 8 categories shown in Table 1 and they are divided into eight parts, with a few barriers from each section being examined to provide a comprehensive view There have been numerous studies on the barriers to CSCM implementation in the leather sector; however, The barriers were identified by studying different papers in the same field and other relevant studies have discussed different barriers related to circular economy supply chain management they are category wise explained and showed at the end of the literature. However, this study aims to discuss the barriers of CSCM under different categories.

A brief discussion about the categorized barriers identified from literature, scholars and experts' opinions as follows:

2.3 Governmental Issues

Implementing circular economy in any industry can be a challenge for developing countries, the approach needs adequate availability of assessment equipment. (Droege, Raggi, & Ramos, 2021) Furthermore, resources like as a budget and human capital should be provided to ensure the CE assessment's design, preparation, implementation, and development. (Droege, Raggi, & Ramos, 2021) Governmental issues highlight the barriers that are caused by lack of government's attention.

2.3.1 Recycling Policies in Waste Management Are Ineffective to Obtain High Quality Recycling, And They Are Affecting the CSCM

Large waste treatment facilities are more expensive and, at times, require complex technology; as a result, the expense of maintenance and employing experienced labor makes the recycling operation expensive, and other less expensive alternatives are useless. (National 3R strategy for waste management, 2010) The policies introduced for recycling are useless to achieve high-quality recyclables as they are ultimately polluting the environment either way. (Man and Friege 2016) On top of that, the lack of mandated requirements is recognized as a key implementation difficulty (Droege, Raggi, & Ramos, 2021). In developing countries, a massive portion of garbage is generated at the consumer end that is not reused or recycled effectively. For sustainable enterprises like CSCM to thrive, high quality recycling must be implemented. (Mangla et al., 2018) According to a paper published by the Ellen MacArthur Foundation, implementing the circular economy might cut material consumption by 32 percent by 2030 and 53 percent by 2050. (Moktadir Govindan & Mia Hasanagic; 2018)

2.3.2 Existing Laws in Waste Management are Not Supporting Circular Economy Supply Chain

Government rules are crucial for supply chain circularity, and a variety of laws and policies serve as the bedrock for critical activities. (Hasanagic and Govindan, 2018) Some waste management legislation, according to Stewart, Bey, and Boks (2016), lack pressure and control in enforcing regulations, which hinders development. (Kazancoglu et al., 2020) Moreover, some of the environmental laws do not align with circular economy ideals in specific systems Yu and Li (2009) This was noted by (Hasanagic and Govindan, 2018) (Rathinamoorthy, 2019). Already in place government rules and regulations are based on a linear economic system and lack proper knowledge of the circular approach, which could stymie the transition to a CSCM 2020. The regulatory authorities in Bangladesh do not actively support CSCM techniques and do not have any regulations to encourage their use in the industrial sector. This is a significant barrier towards CSCM, to lessen its influence on other barriers it must be removed. (Moktadir, M. A., Ahmadi, H. B., Sultana, R., Zohra, F. T., Liou, J. J. H., & Rezaei, J. 2020)

2.4 Economic Issues

With an annual value of about $100 billion, the leather industry makes a significant contribution to the global economy (Pringle, et al, 2016). Waste produced at every stage of the leather goods production life damages the global leather market (Pringle, et al, 2016). Moreover, the weak economy of the country has been considered as one of the problems to implement CSCM, the economic issues consider the utility of product, components and energy and many other things that are hindering CSCM implementation. (Towler, 1996) (Tao et al. 2016), (Zahraee et al. 2016). (Kumar, et al. 2021)

2.4.1 Lack of Long-Term Strategic Goals

Long term strategic objectives are one of vital thing to adapt for the developing countries for its long-term survival in the industry (Moktadir et al. 2020) Being a developing country the most significant roadblock for Bangladesh leather industry to implement CSCM is lack of long-term subjective goals. (Moktadir et al. 2020) For the leather industry's long-term development, producers, like other developing countries, must focus more on defining strategic objectives.

For long term development it is essential that the long-term strategic goals are based on the current companies' trends. The trends help to see cause and effect of the market to set long term goals. (M. A. Moktadir, H. B. Ahmadi, R. Sultana, F. T. Zohra, J. J. H. Liou, and J. Rezaei 2020) Leather industries still have a long way to go thus they should adopt CSCM practices that are environment friendly such as reverse logistics, waste reduction and recycling can help in long term corporate success of the leather industry. (Moktadir et al., 2020)

2.5 Financial Constraints

In sustainability practice financial constraint is a big roadblock (Lin, 2013) (Teixeira et al. 2016) (Vachon, 2007). High-tech technologies, modern infrastructure, and environmental designs are frequently required for sustainable activities. Adapting such technology has proven extremely difficult due to financial constraints. (Syed Mithun Ali, Md. Abdul Moktadir, and Simonov Kusi Sarpong, Towfique Rahman 2019). Among the eight categories of barriers, three barriers from financial constraints have been discussed shown in Table 1. It indicates financial constraints have greater impact on the leather industry

2.5.1 Cost of Disposal of Hazardous Products

The idea of CSCM is comparatively new phenomena that the Bangladeshi manufacturing industries are unaware of, there are also economic benefits associated with using greener products and moving towards CSCM. (Rahman et al., 2019) (Kushwaha 2010) (Sambrani and Pol 2016) Organizations are deterred from implementing a better disposal strategy because they believe the disposal process has significant initial and ongoing costs and no advantages. (Sulaiman, et al. 2015) (Zhu and Sarkis 2004) (Rahman et al, 2019)

The process of disposing hazardous waste substance has a high cost yet long-term benefits but organizations are unaware of that and it makes the implementation of CSCM uncertain. As a result, reducing these barriers with CSCM can aid the leather industry's growth. (Mathiyazhagan et al. 2013) (Petljak et al. 2018) (Walker, Di Sisto, and McBain 2008) (Rahman et al., 2019)

2.5.2 Unavailability of Bank Loans to Encourage Green Products

Due to a dearth of bank funding to assist the development of green products, Bangladesh's leather industry is struggling to put CSCM principles (B42) into practice for consumers (Dubey et al. 2015) (Balasubramanian 2012). Financial institutions serve as a backbone for all businesses, yet they are often unaware of issues such as green product profitability. Because it is difficult for businesses to obtain bank loans for green operations, the CSCM practice is severely hampered. (Mathiyazhagan et al. 2013) (Petljak et al. 2018) (Walker, Di Sisto, and McBain 2008) (Rahman et al., 2019)

2.5.3 Perceived High Initial and Operating Cost

In Bangladesh's leather sector, the high operating cost of constructing a circular supply chain is seen as a key impediment to CSCM implementation. (Kumar et al. 2012) (Mutingi 2013) (Ojo, et al. 2014) (Rahman et al. 2019). To reduce barriers, green operations must be incorporated into the supply chain process, which necessitates the purchase of high-tech equipment as well as the creation of sustainable technologies. All of these factors contribute to high upfront and ongoing costs thus interrupts GSCM practices. (Mathiyazhagan et al. 2013) (Petljak et al. 2018) (Walker, Di Sisto, and McBain 2008) (Rahman et al., 2019) Leather Industries views CSCM implementation as a program with large upfront and ongoing costs and no immediate rewards, so they are discouraged to begin CSCM activities. (Chin et al. 2015) (Zhu and Sarkis 2004) (Rahman et al., 2019).

2.6 Technological Limitations

CSCM is associated with usage of modern technology, the lack of employee training and using advanced facilities is a serious hindrance for Bangladesh. (Kabra et al. 2015) (Walker, Di Sisto, and McBain 2008) (Zhao et al. 2017). Table 1 shows how such limitations can drop the quality of recycled material. Such limitations also limit the access to latest technology, restrict employee's capabilities and competencies on CSCM awareness. (Moktadir, Rahman, Rahman, Ali, & Paul, 2018)

2.6.1 Inability to Deliver the Same Quality as Virgin Products

Virgin products are unprocessed raw materials that has never been processed other than its manufacture. (Trenchlesspedia, 2020). Virgin resources are often inexpensive thus consumers have a very low preference for recycled materials. de Jesus & Mendonça, (2018) (Guarnieri et al. 2020) (Karuppiah et al., 2021). The remanufactured products are a part of CSCM and they are recycled using technology however, the quality of the product does not match with the virgin items even though they are remanufactured the products doesn't give the same feeling like a virgin product hence it is considered as one of the technological barriers of the leather industry. (Yadav et al. 2020) (Accorsi et al. 2020) (Karuppiah, Sankaranarayanan, Ali, Jabbour, & Bhalaji, 2021)

2.7 Organizational policies and issues

The lack of support from government policies and lack of enthusiasm to implement new concepts of sustainability is considered as a barrier to CSCM. Plastic industry of Bangladesh has very minimal recycling facilities built into their operations thus it is making it difficult to establish CSCM and industries are unable to benefit from it. (Moktadir, Rahman, Rahman, Ali, & Paul, 2018)

2.7.1 Unsupportive Organizational and Operational Policy

The support of stakeholders is important to establish proper CSCM in the industry, the program becomes difficult to implement for businesses when there is absence of support from major stakeholders and it is considered as one of the major roadblocks of implementing CSCM (Seman et al. 2012a, 2012b) (Zhu, Sarkis, and Lai 2008a, b) (Lintukangas, Hallikas, and Kahkonen 2013; Tay et al. 2015). (Moktadir, Rahman, Rahman, Ali, & Paul, 2018) In their study, Al Zaabi, Al Dhaheri, and Diabat (2013) found that policies are unsupportive of circular economy techniques. If top management decides to taking action to implement CSCM, it has the potential to have a substantial impact on the leather industry. (Rahman, 2019)

2.8 Management Issues

Issues that arise from management often caused from lack of support from top management, organizational culture and for other priorities in enterprises. (Govindan & Hasanagic, 2018)

2.8.1 Absence of Management Commitment and Approach for CSSM Adoption

A committed managerial approach to sustainable development is the primary driver of environmental changes and advances. (Mangla et al., 2018) To adopt CSCM theories, a thorough CE structure and a realistic plan for implementation are required, which can only be accomplished with management support and a clear plan. However, the management fails to do so. As a result, one of the most significant impediments to CSCM implementation in the leather industry is a lack of managerial approach. (Mangla et al., 2018) (Giunipero, Hooker, and Denslow 2012)

2.9 Circular Economy framework Issues

There is no clear framework of CE on which industries can rely upon thus industries often go through problematic phases even though they want to implement it in the industry. (Govindan & Hasanagic, 2018)

2.9.1 Lack of Successful Business Models and Frameworks to Implement CE In SC

The conventional flow of business model is take-make-consumed which falls under the linear sequence the concept is developed within the circular economy idea. (Lieder and Rashid, 2016) (Urbinati et al., 2017) This concept has been used in various scientific disciples like engineering, industrial ecosystem, cleaner production etc. The lack of such models in the leather industry has led to unsuccessful implementation of CSCM. (Lifset and Graedel, 2002) (Ayres, 1999) (Chertow and Ehrenfeld, 2012) (Ghisellini et al., 2016) (Lieder and Rashid, 2016) (Tukker, 2015) (Welford, 1998). Circular economy hasn't been practiced much thus it doesn't have any successful circular economy business model and framework. To implement CSCM it needs to have informal restoration and inclusion into the framework. (Scheinberg et al. 2016), (Lewandowski 2016) (Govindan & Hasanagic 2018)

2.10 Cultural and Social Issues

The culture is built up in a way that does not encourage or pressurize businesses to practice sustainability in the market. (Govindan & Hasanagic 2018) They have little to no understanding of how it works and how the environment is being polluted. Moreover, the demand for remanufactured products is uncertain. (Karuppiah, Sankaranarayanan, Ali, Jabbour, & Bhalaji, 2021)

2.10.1 Deficiency of Market Mechanisms for Waste Recovery

According to Table 1, lack of market channels for waste recovery is a major problem in implementing CSCM in the leather industry. The reason for such barriers is the government's weak planning strategy. (Karuppiah et al., 2021) Many developed countries are now using cutting edge technology, which is a dependable waste recovery network but the developing countries are terribly falling behind in terms of such competencies. (Karuppiah et al., 2021) Moreover, the amount of people who think about recovering value from waste is very low. Manufacturing industries like leather have huge potential opportunities to make good use of waste and recover them applying CSCM (Karuppiah et al., 2021). The procedure used for recovering the waste making new product after recycling them has little to no scope and its barrier for CSCM implementation. Schroeder et al. (2019); de Jesus & Mendonça (2018); Schroeder et al. (2019); Schroeder et al. (2019); Schroeder

Table 1. Barriers of Circular Supply Chain Management

Category	Barriers	Sources
Governmental Issues	Recycling Policies in Waste Management Are Ineffective to Obtain High Quality Recycling, And They Are Affecting the CSCM	de Man and Friege (2016) Kannan Govindan & Mia Hasanagic (2018)
	Existing Laws in Waste Management are Not Supporting Circular Economy Supply Chain	Li and Yu (2009) Kannan Govindan & Mia Hasanagic (2018)
Economic Issues	Lack of long-term strategic goals	Moktadir, M. A., Ahmadi, H. B., Sultana, R., Zohra, F. T., Liou, J. J. H., & Rezaei, J. (2020)
Financial Constraints	Cost of Disposal of Hazardous Products	Mathiyazhagan et al. 2013; Petljak et al. 2018; Walker, Di Sisto, and McBain 2008)
	Unavailability of Bank Loans to Encourage Green Products	Mathiyazhagan et al. 2013; Petljak et al. 2018; Walker, Di Sisto, and McBain 2008)
	Perceived High Initial and Operating Cost	Mathiyazhagan et al. 2013; Petljak et al. 2018; Walker, Di Sisto, and McBain 2008)
Technological Limitations	Inability to Deliver the Same Quality as Virgin Products	Yadav et al. (2020); Accorsi et al. (2020) (Karuppiah, Sankaranarayanan, Ali, Jabbour, & Bhalaji, 2021)
Organizational policies and issues	Unsupportive Organizational and Operational Policy	(Dashore and Sohani 2013; Jayant and Azhar 2014; Ying and Zhou
Management Issues	Absence of Management Commitment and Approach for CSSM Adoption	(Mangla et al., 2018)
Circular Economy framework Issues	Lack of Successful Business Models and Frameworks to Implement CE In SC	Scheinberg et al. (2016), Lewandowski (2016)

Cultural and Social Issues	Deficiency of Market Mechanisms for Waste Recovery	(Schroeder et al. (2019); de Jesus & Mendonça, (2018)

3. Methodology

For accomplishing the desired outcome Fuzzy DEMATEL method has been used in this paper. The study follows a two-step process where in the first step the most influential barriers are identified by experts and scholars and in the second step these barriers are subjected to Fuzzy DEMATEL technique and followed by drawing casual effect map to understand the influence of the barriers. The following sub section will describe the method in details.

There are few studies done related to leather industry hence in assessing CSCM there are few barriers we have found that are creating a roadblock for the implementation. Tseng (2010a) used fuzzy set theory with gray potential degree to analyze CSCM criteria in supplier selection in a recent study. (Lin, 2013) The study analyses the approaches by using consistency techniques that helps to determine the acceptance and implementation of circular supply chain management in Taiwanese electronics. (Lin, 2013) The fuzzy DEMATEL theory is also used in identifying important aspects in the selection of supply chain management suppliers. The process contributed to identify the aspects that were most influential and established a unique method for suppliers to evaluate their outcomes. (Chang et al., 2011)

The study aims to find out the most influential barriers using the Fuzzy set theory, a suggested method for CSCM criteria. (Lin, 2013) The study will further use the method to overcome distortion and loss of accurate information while assessing the barriers. With the help of the method relationship between the factors will be identified, whether they have high, low, average or no influence on each other. (Lin, 2013) However, large number of data is not mandatory for DEMATEL but with more data the analysis becomes more accurate Chen et al., 2011; Tseng et al., 2009c; Chang et al., 2011; Zhou (Lin, 2013)

3.1 Fuzzy Set Theory

Many organizations have found a way to reach accurate decision using fuzzy theory and organizations are becoming more aware of the correct usage of the theory. Fuzzy helps to deal with ambiguity and vagueness in the form of uncertainty. The preference of human is uncertain for example, human expressions like great, good, bad, not so good involves ambiguity. Hence to get rid of this flaw the paper uses fuzzy set theory. (Islam et al., 2018) (Lin, 2013) Fuzzy set theory helps to make solution in real life situations, which at times involves complex systems such as involving scholars, experts or specialists in decision making and take their help in evaluating the qualitative criteria's. (Lin, 2013) On the basis of membership functions, fuzzy set theory translates qualitative into quantitative data. A triangular fuzzy number can be used as a membership function (TFN). (Lin, 2013) TFN denotes the membership function's range of values (upper, middle, and lower).

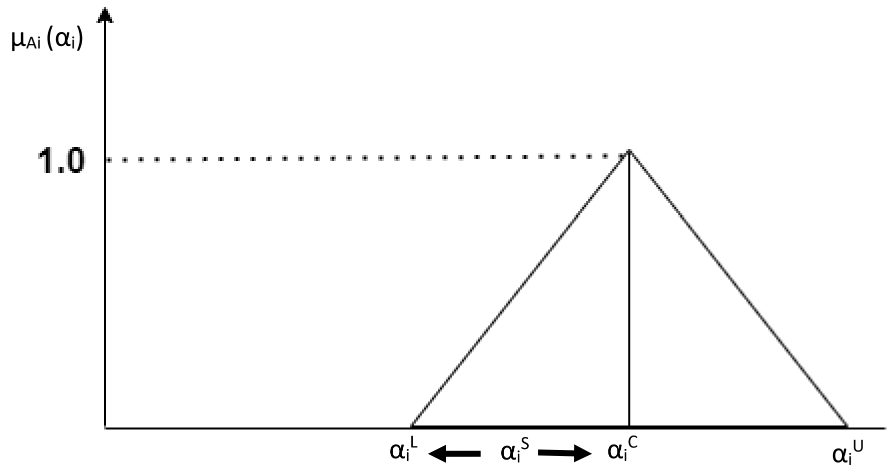

Figure 1: Triangular Fuzzy Model

The highest limit of the perception value is u, the median value is m, and the lower limit of the original perception value is l. (Lin, 2013) Unlike the standard Likert Scale, TFN is widely used and can be used with linguistic variables that originated in human subjective perception. (Islam et al., 2018) TFN denotes the membership function's range of triple (u, m, and l) values. 'u' denotes the perceived value's upper limits'' denotes the perceived value's median or most promising value, and 'l' denotes the perceived value's lower limit (Tseng, Tan & Chiu, 2016) (Lin, 2013). TFN is more widely used than the standard Likert Scale, and linguistic variables derived from human subjective evaluations can be used. (Lin, 2013). TFN is (0.5,0.7, 0.9) where 0.5 refers to lower limit, 0.7 refers to most promising value and 0.9 refers to upper limit. The term "HI" represents high influence on the barriers and its associated TFN is 0.5, 0.7 and 0.9 where 0.5 represent lower limit (l), 0.7 represents middle or most promising value (m) and0.9 represents upper limit (u). Similarly, the term 'VL' represents Very low influence and its associated TFN is 0.1,0.3 and 0.5. (Lin, 2013)

The experts (k) have to integrate the fuzzy weight $\overline{w}_{ji}^{k} = (l_{ji}^{k}, m_{ji}^{k}, u_{ji}^{k})$ of the criteria, and the criteria influenced by the global weights given by the committee of experts to each respondent as parameters. The equations are below,

Normalization process:

$$w_{lij}^{k} = \left(\frac{l_{ji}^{k} - \min l_{ji}^{k}}{\Delta_{m_i n}^{\max}}\right)$$

$$w_{mij}^{k} = \left(\frac{m_{ji}^{k} - \min m_{ji}^{k}}{\Delta_{m_i n}^{\max}}\right) \quad where\ \Delta_{m_i n}^{\max} = max\ u_{ji}^{k} - \min l_{ji}^{k}$$

$$w_{mij}^{k} = \left(\frac{u_{ji}^{k} - \min u_{ji}^{k}}{\Delta_{m_i n}^{\max}}\right)$$

Calculation of left (ls) and right (rs) normalized values:

$$w_{ls} = \frac{x}{(1 + w_{mij}^{k} - w_{lij}^{k}}$$

$$w_{rs} = \frac{x}{(1 + w_{uij}^{k} - w_{mij}^{k}}$$

Developing total normalized crisp value:

$$Z_{ji}^{k} = \frac{[w_{ls}(1 - w_{ls}) + (w_{rs})^2]}{(1 - w_{ls} + w_{rs})}$$

Summation of crisp values.

The aggregate value of the k evaluators subjective perception:

$$\overline{W}_{ji}^{k} = \frac{(\overline{w}_{ls}^{1} + \overline{w}_{ji}^{2} + \overline{w}_{ji}^{3} + \cdots \overline{w}_{ji}^{k}}{(1 - w_{ls} + w_{rs})}$$

Table 2. The Fuzzy Linguistic Scale

Linguistic Variable	Corresponding Triangular fuzzy numbers (TFNs)
No Influence	0,0.1,0.3
Very Low Influence	0.1, 0.3,0.5
Low Influence	0.3,0.5,0.7
High Influence	0.5, 0.7, 0.9
Very High Influence	0.7, 0.9,1

3.2 DEMATEL Method

The Geneva Research Centre of The Battelle Memorial Institute first used the DEMATEL approach in 1973 (Gabus, 1973, #17). DEMATEL is a method for creating and analyzing a structural model for investigating the links between numerous complex criteria. Making decisions to separate complicated components in a fuzzy environment, on the other hand, is highly difficult (Wu, 2007, #48). (2011, Chang et al.) The method is based on graph theory, and users can use it to analyze and solve problems. Researchers will be able to better comprehend the structural relationships between system pieces and find solutions to complicated system problems as a result of this (Gabus and Fontela,1972,1973) (Herrera et al.,2000) (Wang and Chuu, 2004) (Lin 2013)

The fuzzy DEMATEL approach was employed in this work to provide a more accurate analysis (Chang et al., 2011) The DEMATEL is used to convert the linkages between cause-and-effect elements. Assume that a system is made up of elements, and that specific pair-wise relations are chosen for modeling with respect to a C ¼ {c1, c2, c3,..,cn}mathematical relation. The major following steps are:

1. First, the direct relation matrix is created. The comparison scale must be divided into four levels to measure the relationship between criteria: NI (no influence), VL (very low influence), LI (low influence), HI (high influence), and VH (very high impact) (very high influence) An initial direct relation matrix A is a n x n matrix obtained by pair-wise comparisons, in which T_{ij} is denoted as the degree to which the criterion i affects the criterion j, i.e $T = [t_{ij}]_{nxn}$

2. The direct relation matrix is normalized. The normalized direct relation matrix I can be generated using the equation and the direct relation matrix A.

S = k x A

$$K = \frac{1}{\underset{1 \le i \le n}{max}} \in nj = 1a_{ij}$$

3. Obtaining the whole relation matrix is the objective. The total relation matrix I is indicated as the identity matrix once the normalized direct relation matrix S has been generated.

T = X (1 – X) – 1

4. Creating a cause-and-effect diagram. Within the complete relation matrix M, the sum of rows and columns are denoted by the vectors D and R, respectively. Lin (2013) The dataset (D + R, D - R) can be mapped to create a causal and effect graph. By adding D to R, the horizontal axis vector "Prominence" is created, which indicates how important the condition is. Similarly, the "Relation" vertical axis (D - R) is created by subtracting D from R, which can be used to group criteria into a cause group. Lin (2013) The criterion is grouped into the effect group if the (D -R) is negative.

$$T = [t_{ij}]_{nxn\ I,j = 1,2,\ldots..n}$$

$$D = [\textstyle\sum_{i=1}^{n} t_{ij}]_{1xn} = [t_j]_{nx1}$$

$R = [\sum_{j=1}^{n} t_{ij}]_{1xn} = [t_j]_{nx1}$

The inner dependence matrix is formed. The normalization approach is used to make the sum of each column in the total relation matrix equal to 1, and then the inner dependence matrix can be generated.

3.3 Fuzzy DEMATEL application procedure

The method followed a few steps to identify the influence, the analysis followed the procedures below,

Step 1: Gathering barriers by studying other papers: The method needed relevant barriers related to the leather industry from other papers. So, the first step included collecting barriers that other papers mentioned prevailed in the leather industry. In the first step, around 34 barriers were collected from studying different papers. It was necessary to collect these barriers to send it to scholars and experts for sorting.

Step 2: Evaluation criteria and survey instruments play a pivotal role to establish an understanding of the survey. The second step of the survey was followed by an online survey done in google form where all 34 survey questions were put in a form and the google form was sent to 5 experts and scholars to identify the most influential barriers according to them and after sorting 17 barriers were found which the experts thought closely connected with the leather industry.

Step 3: The survey's barriers were interpreted using linguistic data to transform unclear numbers into a precise score. The values were entered in linguistics form using HI, VL, NI, and VH, and the values were then used to convert fuzzy numbers into crisp scores. The fuzzy evaluations are defuzzified and summed to obtain a crisp value.

Step 4: In the last step of the analysis the casual and effect diagram is analyzed. The crisp value is composed of the initial direct relation matrix.

4. Results

The outcome of fuzzy DEMATEL in the leather sector will be evaluated in this part. The accuracy of the results is why Fuzzy DEMATEL was chosen for identifying critical barriers to circular supply chain management in Bangladesh's leather sector. The leather business continues to damage areas, and the only treatment that can be implemented in this industry is to apply circular supply chain management. The industry needs to follow CSCM to get over this crisis in leather industry. In this study 3 experts and two scholars have participated with extensive understanding on the field and experience. This study attempts to apply Fuzzy DEMATEL to identify the critical barriers to implement CSCM in the leather industry of Bangladesh. The process has proposed four following steps:

Step 1: Gathering relevant data and defining goals for further improving the seventeen CSCM criteria in order to study the interrelationships of criteria in uncertain situations.

Step 2: In total seventeen criteria were assessed, (A1), (A2), (A3), (A4), (A5), (A6), (A7), (A8), (A9), (A10), (A11), (A12), (A13), (A14), (A15), (A16), (A17). To test the impact of each criteria the Fuzzy DEMATEL approach has been used. The respondents were asked to rate the interdependence of each criterion using on a scale of (NI) no influence, (VL) very low influence,

(HI) high influence, (VH) very high influence. It is vital to consult experts in order to validate information about the criteria influences and directions utilizing a survey instrument. See more in Table 1 linguistic value and Table 4 Direct relation matrix.

Step 3: In this step the linguistic data is converted into a fuzzy scaled linguistic scale. It is used to standardize the assessment and obtain empirical data from each individual respondent. He DEMATEL initial direct relation matrix is obtained using the equations.

Step 4: The relation matrix helped the crisp value of CSCM criteria from the fuzzy assessment. He entire relation matrix can be obtained using the formula of T. (Lin, 2013)

Table 3. Sample Response Table of Expert 1

E1	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**	**A13**	**A14**	**A15**	**A16**	**A17**
A1	1	LI	LI	HI	LI	HI	HI	HI	HI	LI	LI	NI	HI	HI	VL	VH	VH
A2	HI	1	VH	LI	LI	VL	NI	VL	LI	HI	NI	HI	VH	LI	HI	VH	LI
A3	VH	LI	1	NI	HI	NI	NI	NI	VH	LI	HI	LI	VH	VH	NI	LI	HI
A4	NI	NI	LI	1	HI	NI	HI	VH	LI	VH	VH	LI	NI	NI	NI	LI	VH
A5	HI	LI	HI	HI	1	LI	VL	NI	VL	LI	HI	NI	HI	VH	LI	HI	VH
A6	HI	NI	NI	HI	LI	1	VH	VH	LI	HI	NI	VH	HI	LI	LI	VH	VH
A7	LI	LI	HI	NI	HI	VH	1	VH	LI	HI	LI	VH	VH	NI	NI	LI	VL
A8	VH	LI	LI	VL	LI	LI	VH	1	VH	HI	VL	LI	NI	MI	LI	LI	LI
A9	VH	LI	LI	HI	VL	HI	VH	HI	1	VH	NI	LI	LI	NI	NI	NI	VL
A10	VH	VH	HI	LI	HI	VH	HI	LI	LI	1	HI	VH	LI	LI	HI	NI	VH
A11	NI	LI	LI	VL	HI	LI	NI	NI	LI	VH	1	LI	VH	VH	HI	LI	HI
A12	VH	LI	LI	HI	LI	HI	LI	VH	LI	NI	NI	1	VH	VH	NI	LI	VL
A13	NL	VH	HI	LI	NL	NL	HI	LI	VH	VH	HI	LI	1	VH	LI	VL	LI
A14	LI	HI	HI	LI	VH	VH	HI	LI	HI	VH	HI	VH	LI	1	VH	NI	LI
A15	HI	LI	HI	NI	HI	VH	LI	HI	VH	LI	VH	LI	NI	NI	1	VH	HI
A16	NI	VH	LI	HI	LI	VH	VH	NI	LI	HI	LI	VH	LI	NI	VH	1	VH
A17	HI	VH	LI	NI	LI	VL	NI	VL	LI	HI	NI	HI	VH	LI	HI	VH	1

Table 4. Direct Relation Matrix

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17
A1	0.091	0.056	0.056	0.061	0.049	0.057	0.052	0.052	0.061	0.052	0.060	0.037	0.049	0.067	0.050	0.077	0.073
A2	0.065	0.091	0.077	0.039	0.049	0.049	0.026	0.035	0.043	0.061	0.026	0.058	0.067	0.045	0.067	0.067	0.065
A3	0.074	0.052	0.091	0.048	0.037	0.046	0.039	0.031	0.060	0.060	0.065	0.058	0.049	0.067	0.041	0.041	0.048
A4	0.031	0.047	0.043	0.091	0.066	0.050	0.065	0.056	0.048	0.061	0.052	0.024	0.024	0.041	0.041	0.041	0.060
A5	0.048	0.043	0.061	0.044	0.094	0.071	0.047	0.052	0.056	0.061	0.061	0.045	0.054	0.075	0.058	0.058	0.065
A6	0.061	0.035	0.035	0.065	0.054	0.090	0.060	0.044	0.047	0.047	0.026	0.049	0.049	0.067	0.062	0.062	0.048
A7	0.056	0.052	0.039	0.022	0.066	0.056	0.090	0.052	0.043	0.039	0.035	0.054	0.058	0.028	0.050	0.050	0.030
A8	0.061	0.060	0.039	0.048	0.058	0.057	0.047	0.091	0.052	0.039	0.056	0.049	0.032	0.058	0.049	0.049	0.048
A9	0.052	0.039	0.060	0.056	0.036	0.049	0.073	0.065	0.092	0.047	0.026	0.058	0.062	0.045	0.028	0.028	0.048
A10	0.052	0.065	0.052	0.056	0.058	0.055	0.048	0.044	0.030	0.091	0.052	0.071	0.037	0.049	0.054	0.054	0.065
A11	0.039	0.044	0.043	0.048	0.050	0.056	0.030	0.048	0.056	0.069	0.091	0.049	0.050	0.063	0.024	0.024	0.043
A12	0.073	0.035	0.048	0.065	0.062	0.056	0.039	0.051	0.052	0.035	0.039	0.095	0.062	0.071	0.037	0.037	0.052
A13	0.044	0.070	0.052	0.064	0.045	0.047	0.057	0.047	0.077	0.073	0.048	0.024	0.095	0.049	0.049	0.049	0.069
A14	0.043	0.039	0.061	0.039	0.049	0.051	0.052	0.048	0.057	0.060	0.061	0.071	0.045	0.094	0.062	0.062	0.047
A15	0.065	0.043	0.052	0.052	0.045	0.069	0.052	0.056	0.056	0.056	0.051	0.032	0.050	0.028	0.095	0.095	0.048
A16	0.039	0.044	0.043	0.048	0.045	0.070	0.052	0.043	0.056	0.052	0.056	0.066	0.049	0.054	0.071	0.071	0.069
A17	0.065	0.039	0.031	0.043	0.049	0.056	0.026	0.035	0.052	0.060	0.044	0.063	0.058	0.041	0.058	0.058	0.092

Study findings from the casual diagram is described below. The evaluation criteria are as follows: (A1) Recycling policies in waste management are ineffective to obtain high quality recycling, and they are affecting the CSCM. (A2) Lack of support and guidelines from regulatory authorities. (A3) Deficient organizational structure of the companies to adopt CSCM. (A4) High purchasing cost of environmentally friendly materials by the supplier. (A5) Lack of long-term strategic goals. (A6) Lack of long-term strategic goals. (A7) Unavailability of bank loans to encourage green products. (A8) Lack of modern technologies facility of storage and Transportation. (A9) Maintaining quality of products made from recovered material. (A10) Lack of recycling and reuse facilities of organizations. (A11) Limited willingness to collaborate in the value chain. (A12) Lack of waste management. (A13) Absence of management commitment and approach for CSSM adoption. (A14) Lack of guidelines for quality of refurbishment products. (A15) Other solutions might be more favorable than implementing CE in SC. (A16) Deficiency of market mechanisms for waste recovery. (A17) Lack of enthusiasm towards CE in SC.

Table 5. Total Relation Matrix

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	D
A1	0.724	0.615	0.636	0.648	0.651	0.707	0.617	0.610	0.680	0.689	0.619	0.634	0.635	0.690	0.641	0.689	0.716	**11.200**
A2	0.662	0.619	0.625	0.592	0.614	0.659	0.555	0.557	0.625	0.660	0.550	0.620	0.620	0.630	0.625	0.643	0.670	**10.524**
A3	0.648	0.559	0.619	0.581	0.581	0.633	0.550	0.535	0.621	0.638	0.572	0.600	0.581	0.633	0.575	0.592	0.628	**10.146**
A4	0.556	0.513	0.525	0.580	0.570	0.591	0.536	0.522	0.561	0.591	0.517	0.520	0.509	0.558	0.533	0.548	0.594	**9.323**
A5	0.678	0.599	0.639	0.628	0.695	0.719	0.610	0.608	0.673	0.695	0.618	0.641	0.637	0.697	0.647	0.666	0.703	**11.153**
A6	0.632	0.539	0.557	0.596	0.598	0.678	0.573	0.548	0.606	0.621	0.529	0.588	0.578	0.629	0.598	0.615	0.626	**10.110**
A7	0.577	0.513	0.516	0.504	0.563	0.591	0.557	0.511	0.552	0.561	0.493	0.545	0.542	0.538	0.537	0.553	0.556	**9.206**
A8	0.626	0.560	0.556	0.572	0.596	0.637	0.552	0.592	0.604	0.606	0.555	0.583	0.554	0.615	0.577	0.594	0.619	**9.999**
A9	0.597	0.521	0.559	0.562	0.554	0.607	0.562	0.547	0.626	0.593	0.504	0.572	0.568	0.579	0.534	0.550	0.598	**9.634**
A10	0.643	0.587	0.593	0.605	0.621	0.662	0.574	0.564	0.605	0.687	0.573	0.631	0.583	0.631	0.606	0.624	0.664	**10.453**
A11	0.558	0.503	0.520	0.531	0.545	0.589	0.493	0.506	0.564	0.594	0.552	0.541	0.531	0.576	0.506	0.522	0.570	**9.201**
A12	0.651	0.544	0.577	0.603	0.613	0.649	0.555	0.562	0.617	0.614	0.549	0.641	0.598	0.642	0.575	0.593	0.637	**10.220**
A13	0.647	0.607	0.607	0.626	0.620	0.668	0.598	0.580	0.670	0.684	0.580	0.593	0.657	0.642	0.614	0.632	0.683	**10.708**
A14	0.638	0.564	0.607	0.591	0.616	0.663	0.584	0.573	0.639	0.659	0.588	0.636	0.597	0.683	0.619	0.637	0.650	**10.544**
A15	0.664	0.572	0.600	0.609	0.615	0.686	0.588	0.585	0.642	0.659	0.580	0.596	0.604	0.615	0.657	0.676	0.655	**10.604**
A16	0.622	0.558	0.577	0.590	0.600	0.671	0.574	0.558	0.627	0.639	0.571	0.619	0.591	0.628	0.618	0.635	0.661	**10.339**
A17	0.618	0.526	0.535	0.557	0.574	0.624	0.518	0.521	0.592	0.616	0.530	0.584	0.571	0.584	0.575	0.592	0.654	**9.771**
R	**10.742**	**9.499**	**9.847**	**9.975**	**10.225**	**11.035**	**9.596**	**9.480**	**10.505**	**10.806**	**9.481**	**10.144**	**9.956**	**10.568**	**10.035**	**10.360**	**10.884**	**0.599**

Table 6. The prominence and relation axis for cause-and-effect group

	D	R	D+R	D-R
A1	11.200	10.742	21.942	0.458
A2	10.524	9.499	20.023	1.026
A3	10.146	9.847	19.993	0.299
A4	9.323	9.975	19.298	-0.651
A5	11.153	10.225	21.377	0.928
A6	10.110	11.035	21.145	-0.925
A7	9.206	9.596	18.803	-0.390
A8	9.999	9.480	19.479	0.520
A9	9.634	10.505	20.139	-0.870
A10	10.453	10.806	21.259	-0.353
A11	9.201	9.481	18.682	-0.279
A12	10.220	10.144	20.364	0.076
A13	10.708	9.956	20.664	0.752
A14	10.544	10.568	21.112	-0.023
A15	10.604	10.035	20.639	0.569
A16	10.339	10.360	20.698	-0.021
A17	9.771	10.884	20.655	-1.113

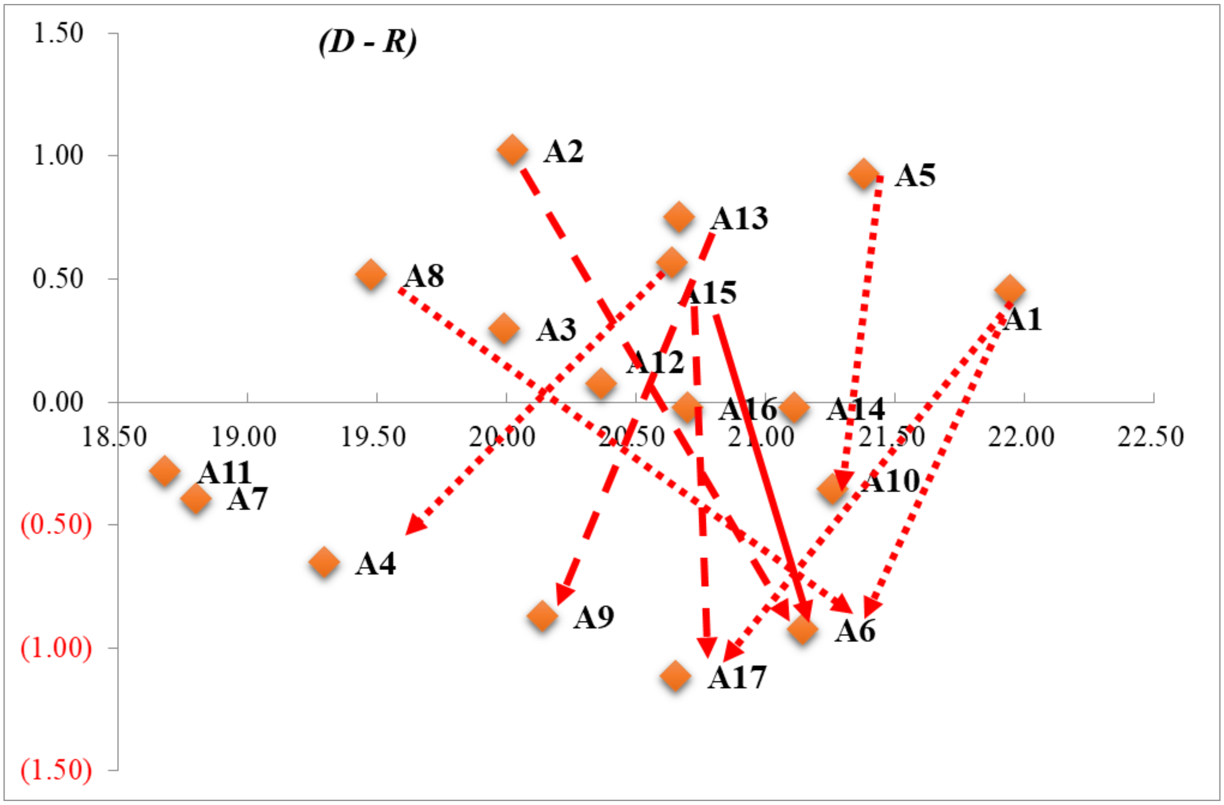

Figure 2: Cause and Effect Diagram

Min	0.5992
Average	0.6397
Higher	0.6819
Max	0.7241

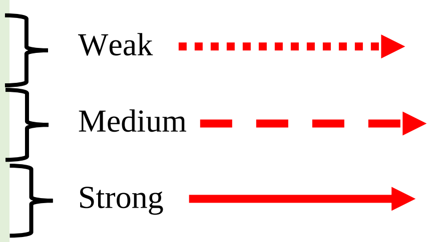

Figure 3: Influence Level

The cause variables have a remarkable impact on the industry's overall goal, and they affect the whole system. (A15) has the highest influence on (A6) with a value of 0.6862 means A15 is the causal factor while A6 is the effect factor. The (D-R) of (A15) is 0.5688 and the (D+R) is 20.6390 which is considerably higher than other few factors. (A15) is the most influencing factor in the diagram and (A6) is the effect of that cause. (A15) also has influence on (A4) with a number of 0.6088 which is comparatively weaker and has little influence. Other than that (A1) and (A8) has low influence on (A6), the (D-R) value of (A8) is 0.5198 and for (A1) 0.4579. However, (A1) has the highest (D+R) with a number of 21.9417 which means it has high potentiality to be influenced bb other factors. Other than that, the diagram also shoes (A13) have medium influence on (A9) and (A17). The (D+R) value for (A9) is 20.1390 and (A13) is 20.6642 which makes them very close to each of the factors. Effect factors are easily altered by others, they are inappropriate as critical success factors. However, in order to determine each factor's distinct qualities, it is still necessary to address influence factors. The diagram lastly shows (A5) has weak influence on (A10). Their interception point has a value of 0.6954. The (D+R) value of (A10) is 21.2592 which shows it has an impact on the entire industry, despite being an effect factor. According to the diagram, (A15) has a strong impact on (A6) indicating that one is influencing the other to happen in the industry while also having a significant impact on them.

5. Managerial Implications

The aim of the study is to identify the most critical barrier among the 17 barriers that has been discussed here. The findings had several managerial implications that will discussed below. The cause-and-effect groups has impact on the derived outcome. (Lin, 2013) The cause group have major impact on the system and the factors in the effect group. It is important to identify the cause-and-effect factor from the figure as it will it is the most important part of the method

(Falatoonitoosi et al., 2014) however; the cause group criteria are more difficult to carry out while the effect group criteria are easily conducted. (Lin, 2013).

The diagram above shows A15 is affecting A6 to happen and the impact is high. (A15) The CSCM is primarily concerned with recycling and improving the rate of recycling. Other solutions, on the other hand, might be preferred. Other solutions might me more favorable or worse thus its affecting (A6) cost of hazardous products disposal. It also has weak influence on (A4) the supplier's high purchasing cost of ecofriendly materials. The managers must look into it and try to compare and contrast CSCM and other options. The diagram is also showing A1, A2 and A8 is also inducing A6 to happen. (A1) Recycling waste management standards are unsuccessful in achieving high-quality recycling, which is something industry management should aim to improve because pollution is increasing as a result of this Furthermore, (A8) lack of advanced technologies, storage facilities, and transportation is to blame for the inability to dispose of (A6) hazardous products, as disposal requires high-tech machines and experts, and (A2) regulatory authorities do not provide clear guidelines or demonstrate support, causing the disposal system to be hampered.

However, the management should concentrate on resolving all of the root causes, particularly A15, which has a strong impact on the effect factor A6 while A1, (A2), and (A8) have a slight to medium impact. The diagram also shows (A13) has a medium impact on (A9) and (A17). (A13) Lack of management commitment and strategy are hampering CSSM adoption and as a result it has been difficult to produce (A9) high-quality product out of recycled materials and the industry is also losing enthusiasm in establishing in SC.

The management should be more concrete to its commitment and introduce new strategies to adopt CSCM so that the industry can produce high quality recycled product and doesn’t lose enthusiasm to adopt CSCM. Lastly, the diagram shows (A5) have impact on (A10) which is comparatively weaker. (A5) Due to long terms goals in the leather industry for CSCM implementation the (A10) Organizations can't afford Effluent Treatment Plants to recycle garbage and utilize it. For the leather industry's long-term success, producers must work on improving strategic goals. Long-term strategic objectives based on current business trends are essential for long-term success. Moktadir, M. A., Ahmadi, H. B., Sultana, R., Zohra, F. T., Liou, J. J. H., & Rezaei, J. (2020) Moreover, the suppliers should maintain the quality of products made from recovered material as its bit expensive to convert yet it should be something that is long lasting and can be reused. The authorities should encourage to produce such products. Organizations should be more (A10) aware of recycling and reuse facilities as lack of such facilities is causing excessive pollution in the environment thus, they should reconsider this matter. The government should allocate specialized resources to let this industry flourish in a pollution free environment thus the government should be more considerate giving bank loans (A7), plan jointly with private and public companies to (A14) address environmental issues and take necessary steps for waste mitigation. (Vachon and Klassen, 2006). (Lin, 2013)

6. Concluding Remarks

Circular supply chain management is becoming increasingly important for many industries, particularly manufacturing. Natural resources are going extinct as the world's population is rapidly growing. Sustainable methods can only help to restore the nature by recycling hazardous product. The goal of this article was to identify the challenges to CSCM implementation in Bangladesh's leather sector. The leather industry is already a good economic resource for Bangladesh, but it is becoming increasingly detrimental to people living near the industry region as well as the environment owing to lack of care and adequate recycling.

This is an issue that the government and stakeholders must solve, and this study will play an important role in raising awareness about the need of protecting the environment and human lives through CSCM. The government, stakeholders, and businesses can all learn about the major roadblocks to CSCM implementation and take the necessary steps to save the environment. The work used the Fuzzy DEMATEL method, which was the best method for this research. The strategy avoids ambiguities and inaccurate judgments in order to find the significant hurdles. The study provides result from the cause-and-effect diagram which shows (A15) The CSCM is primarily concerned with recycling and improving the rate of recycling. (A2) regulatory authorities do not provide clear guidelines or demonstrate support. (A8) Lack of advanced technologies, storage facilities, and transportation. (A13) Lack of management commitment and strategy are hampering CSSM adoption these factors are in cause group thus they need to be improved.

However, the research, have several flaws. To begin with, the survey received a low number of responses. Only professionals and scholars are eligible to engage in this procedure, therefore persuading them to take part in this lengthy survey was tough. Second, there is a dearth of previous quality studies, which has resulted in difficulties in collecting data on the leather industry's barriers. Because there has been so few research in this sector, gathering data has been challenging. More papers and empirical investigations on this industry should be published in the future.

7. Reference

- Govindan, K., & Hasanagic, M. (2018). A systematic review on drivers, barriers, and practices towards Circular Economy: A Supply Chain Perspective. International Journal of Production Research, 56(1-2), 278-311. doi:10.1080/00207543.2017.1402141
- Karuppiah, K., Sankaranarayanan, B., Ali, S. M., Jabbour, C. J., & Bhalaji, R. (2021). Inhibitors to circular economy practices in the leather industry using an integrated approach: Implications for Sustainable Development Goals in emerging economies. Sustainable Production and Consumption, 27, 1554-1568. doi:10.1016/j.spc.2021.03.015
- Kumar, P., Singh, R. K., & Kumar, V. (2021). Managing supply chains for sustainable operations in the era of Industry 4.0 and circular economy: Analysis of barriers. Resources, Conservation and Recycling, 164, 105215. doi:10.1016/j.resconrec.2020.105215
- Mangla, S. K., Luthra, S., Mishra, N., Singh, A., Rana, N. P., Dora, M., & Dwivedi, Y. (2018). Barriers to effective circular supply chain management in a developing country context. Production Planning & Control, 29(6), 551-569. doi:10.1080/09537287.2018.1449265
- Moktadir, M. A., Ali, S. M., Rajesh, R., & Paul, S. K. (2018). Modeling the interrelationships among barriers to sustainable supply chain management in Leather Industry. Journal of Cleaner Production, 181, 631-651. doi:10.1016/j.jclepro.2018.01.245
- Sun, D. (n.d.). Hazaribagh Tannery-era ends today: Daily sun |. Retrieved April 7, 2022, from https://www.daily-sun.com/printversion/details/217549/Hazaribagh-tanneryera-ends-today

- Wojno, R. (2020, January 26). These 5 countries are totally nailing sustainability. Retrieved April 8, 2022, from https://www.goodnet.org/articles/these-5-countries-are-totally-nailing-sustainability
- Tseng, M.-L., Islam, M. S., Karia, N., Fauzi, F. A., & Afrin, S. (2019). A literature review on Green Supply Chain Management: Trends and future challenges. Resources, Conservation and Recycling, 141, 145–162. https://doi.org/10.1016/j.resconrec.2018.10.009
- An AHP framework to evaluate barriers and potential tensions to green supply chain management in the food and beverage industry. (2021). European Journal of Business and Management. https://doi.org/10.7176/ejbm/13-6-01
- Dieckmann, E., Sheldrick, L., Tennant, M., Myers, R., & Cheeseman, C. (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. https://doi.org/10.3390/su12051725
- Moktadir, M. A., Ahmadi, H. B., Sultana, R., Zohra, F.-T.-, Liou, J. J. H., & Rezaei, J. (2020). Circular economy practices in the leather industry: A practical step towards Sustainable Development. Journal of Cleaner Production, 251, 119737. https://doi.org/10.1016/j.jclepro.2019.119737
- Islam, M. S., Tseng, M.-L., & Karia, N. (2019). Assessment of corporate culture in sustainability performance using a hierarchical framework and interdependence relations. Journal of Cleaner Production, 217, 676–690. https://doi.org/10.1016/j.jclepro.2019.01.259

- Liu, Y., Wood, L. C., Venkatesh, V. G., Zhang, A., & Farooque, M. (2021). Barriers to sustainable food consumption and production in China: A fuzzy DEMATEL analysis from a circular economy perspective. Sustainable Production and Consumption, 28, 1114–1129. https://doi.org/10.1016/j.spc.2021.07.028
- Mastos, T. D., Nizamis, A., Terzi, S., Gkortzis, D., Papadopoulos, A., Tsagkalidis, N., Ioannidis, D., Votis, K., & Tzovaras, D. (2021). Introducing an application of an industry 4.0 solution for circular supply chain management. Journal of Cleaner Production, 300, 126886. https://doi.org/10.1016/j.jclepro.2021.126886
- Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The circular economy – a new sustainability paradigm? Journal of Cleaner Production, 143, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048
- Moktadir, M. A., Rahman, T., Rahman, M. H., Ali, S. M., & Paul, S. K. (2018). Drivers to sustainable manufacturing practices and Circular Economy: A perspective of leather industries in Bangladesh. Journal of Cleaner Production, 174, 1366–1380. https://doi.org/10.1016/j.jclepro.2017.11.063
- Kumar, P., Singh, R. K., & Kumar, V. (2021). Managing supply chains for sustainable operations in the era of Industry 4.0 and circular economy: Analysis of barriers. Resources, Conservation and Recycling, 164, 105215. https://doi.org/10.1016/j.resconrec.2020.105215
- Jain, S., Jain, N. K., & Metri, B. (2018). Strategic framework towards measuring a circular supply chain management. Benchmarking: An International Journal, 25(8), 3238–3252. https://doi.org/10.1108/bij-11-2017-0304

- Liu, J. (2019). The circular economy and Green Supply Chain Management. Handbook on the Sustainable Supply Chain, 27–43. https://doi.org/10.4337/9781786434272.00007
- Abad-Segura, E., Fuente, A. B., González-Zamar, M.-D., & Belmonte-Ureña, L. J. (2020). Effects of circular economy policies on the environment and sustainable growth: Worldwide research. Sustainability, 12(14), 5792. https://doi.org/10.3390/su12145792
- Genovese, A., Acquaye, A. A., Figueroa, A., & Koh, S. C. L. (2017). Sustainable Supply Chain Management and the transition towards a circular economy: Evidence and some applications. Omega, 66, 344–357. https://doi.org/10.1016/j.omega.2015.05.015
- Masi, D., Kumar, V., Garza-Reyes, J. A., & Godsell, J. (2018). Towards a more circular economy: Exploring the awareness, practices, and barriers from a focal firm perspective. Production Planning & Control, 29(6), 539–550. https://doi.org/10.1080/09537287.2018.1449246
- Jaeger, B., & Upadhyay, A. (2020). Understanding barriers to circular economy: Cases from the manufacturing industry. Journal of Enterprise Information Management, 33(4), 729–745. https://doi.org/10.1108/jeim-02-2019-0047
- Lin, R.-J. (2013). Using fuzzy DEMATEL to evaluate the Green Supply Chain Management Practices. Journal of Cleaner Production, 40, 32–39. https://doi.org/10.1016/j.jclepro.2011.06.010

- Abad-Segura, E., Fuente, A. B., González-Zamar, M.-D., & Belmonte-Ureña, L. J. (2020). Effects of circular economy policies on the environment and sustainable growth: Worldwide research. Sustainability, 12(14), 5792. https://doi.org/10.3390/su12145792

- Dieckmann, E., Sheldrick, L., Tennant, M., Myers, R., & Cheeseman, C. (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. https://doi.org/10.3390/su12051725

- Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The circular economy – a new sustainability paradigm? Journal of Cleaner Production, 143, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048
- Genovese, A., Acquaye, A. A., Figueroa, A., & Koh, S. C. L. (2017). Sustainable Supply Chain Management and the transition towards a circular economy: Evidence and some applications. Omega, 66, 344–357. https://doi.org/10.1016/j.omega.2015.05.015
- Jaeger, B., & Upadhyay, A. (2020). Understanding barriers to circular economy: Cases from the manufacturing industry. Journal of Enterprise Information Management, 33(4), 729–745. https://doi.org/10.1108/jeim-02-2019-0047
- Jain, S., Jain, N. K., & Metri, B. (2018). Strategic framework towards measuring a circular supply chain management. Benchmarking: An International Journal, 25(8), 3238–3252. https://doi.org/10.1108/bij-11-2017-0304
- Kumar, P., Singh, R. K., & Kumar, V. (2021). Managing supply chains for sustainable operations in the era of Industry 4.0 and circular economy: Analysis of barriers. Resources, Conservation and Recycling, 164, 105215. https://doi.org/10.1016/j.resconrec.2020.105215
- Lin, R.-J. (2013). Using fuzzy DEMATEL to evaluate the Green Supply Chain Management Practices. Journal of Cleaner Production, 40, 32–39. https://doi.org/10.1016/j.jclepro.2011.06.010
- Liu, J. (2019). The circular economy and Green Supply Chain Management. Handbook on the Sustainable Supply Chain, 27–43. https://doi.org/10.4337/9781786434272.00007

- Mastos, T. D., Nizamis, A., Terzi, S., Gkortzis, D., Papadopoulos, A., Tsagkalidis, N., Ioannidis, D., Votis, K., & Tzovaras, D. (2021). Introducing an application of an industry 4.0 solution for circular supply chain management. Journal of Cleaner Production, 300, 126886. https://doi.org/10.1016/j.jclepro.2021.126886
- Tseng, M.-L., Islam, M. S., Karia, N., Fauzi, F. A., & Afrin, S. (2019). A literature review on Green Supply Chain Management: Trends and future challenges. Resources, Conservation and Recycling, 141, 145–162. https://doi.org/10.1016/j.resconrec.2018.10.009
- Lahane, S., Kant, R., & Shankar, R. (2020). Circular Supply Chain Management: A state-of-art review and future opportunities. Journal of Cleaner Production, 258, 120859. https://doi.org/10.1016/j.jclepro.2020.120859
- Karn, S.K. and Harada, H. (2001) Surface Water Pollution in Three Urban Territories of Nepal, India, and Bangaldesh. Environmental Management, 28, 483-496. https://doi.org/10.1007/s002670010238
- Kalmykova, Y., Sadagopan, M., & Rosado, L. (2018). Circular economy – from review of theories and practices to development of Implementation Tools. Resources, Conservation and Recycling, 135, 190–201. https://doi.org/10.1016/j.resconrec.2017.10.034
- Korhonen, J., Honkasalo, A., & Seppälä, J. (2018). Circular economy: The concept and its limitations. Ecological Economics, 143, 37–46. https://doi.org/10.1016/j.ecolecon.2017.06.041

- Schroeder, P., Anggraeni, K., & Weber, U. (2018). The relevance of circular economy practices to the Sustainable Development Goals. Journal of Industrial Ecology, 23(1), 77–95. https://doi.org/10.1111/jiec.12732
- Komoto, H., Tomiyama, T., Silvester, S., & Brezet, H. (2011). Analyzing supply chain robustness for oems from a life cycle perspective using life cycle simulation. International Journal of Production Economics, 134(2), 447–457. https://doi.org/10.1016/j.ijpe.2009.11.017
- De Angelis, R., Howard, M., & Miemczyk, J. (2018). Supply Chain Management and the circular economy: Towards the circular supply chain. Production Planning & Control, 29(6), 425–437. https://doi.org/10.1080/09537287.2018.1449244
- Droege, H., Raggi, A., & Ramos, T. B. (2021). Overcoming current challenges for circular economy assessment implementation in public sector organisations. Sustainability, 13(3), 1182. https://doi.org/10.3390/su13031182
- de Man, R., & Friege, H. (2016). Circular economy: European policy on Shaky Ground. Waste Management & Research: The Journal for a Sustainable Circular Economy, 34(2), 93–95. https://doi.org/10.1177/0734242x15626015
- Kazancoglu, I., Kazancoglu, Y., Yarimoglu, E., & Kahraman, A. (2020). A conceptual framework for barriers of circular supply chains for sustainability in the textile industry. Sustainable Development, 28(5), 1477–1492. https://doi.org/10.1002/sd.2100
- Circular economy in textiles and apparel. (2019). https://doi.org/10.1016/c2017-0-03221-4
- Li, E. L., Zhou, L., & Wu, A. (2017). The supply-side of environmental sustainability and export performance: The Role of Knowledge Integration and international buyer

involvement. International Business Review, 26(4), 724–735. https://doi.org/10.1016/j.ibusrev.2017.01.002

- Lintukangas, K., Hallikas, J., & Kähkönen, A.-K. (2013). The role of Green Supply Management in the development of Sustainable Supply Chain. Corporate Social Responsibility and Environmental Management, 22(6), 321–333. https://doi.org/10.1002/csr.1348
- Trenchless Solutions through education. Trenchlesspedia. (n.d.). Retrieved June 22, 2022, from https://www.trenchlesspedia.com/
- Zhu, Q., Sarkis, J., & Lai, K.-hung. (2007). Green Supply Chain Management: Pressures, practices and performance within the Chinese Automobile Industry. Journal of Cleaner Production, 15(11-12), 1041–1052. https://doi.org/10.1016/j.jclepro.2006.05.021
- Urbinati, A., Chiaroni, D., & Chiesa, V. (2017). Towards a new taxonomy of circular economy business models. Journal of Cleaner Production, 168, 487–498. https://doi.org/10.1016/j.jclepro.2017.09.047
- Korhonen, J., Nuur, C., Feldmann, A., & Birkie, S. E. (2018). Circular economy as an essentially contested concept. Journal of Cleaner Production, 175, 544–552. https://doi.org/10.1016/j.jclepro.2017.12.111
- Agyemang, M., Kusi-Sarpong, S., Khan, S. A., Mani, V., Rehman, S. T., & Kusi-Sarpong, H. (2019). Drivers and barriers to circular economy implementation. Management Decision, 57(4), 971–994. https://doi.org/10.1108/md-11-2018-1178

8. Appendix

DEMATEL Questionnaire

Category	Survey Questionnaire
Governmental Issues (Please check 3 most relevant items from the list below)	Recycling policies in waste management are ineffective to obtain high quality recycling, and they are affecting the CSCM (Circular Supply Chain Management)
	Existing laws in waste management are not supporting Circular economy supply chain
	Deficient organizational structure of the companies to adopt GSCM (Green Supply Chain Management)
	Lack of support and guidelines from regulatory authorities
Economic Issues (Please check 3 most relevant items from the list below)	Cost of sustainability and economic conditions
	High purchasing cost of environmentally friendly materials by the supplier
	Weak economic incentives make it difficult for enterprises to implement CE in SC

	Lack of long-term strategic goals
Financial Constraints (Please check 3 most relevant items from the list below)	Unavailability of bank loans to encourage green products
	Cost of disposal of hazardous products
	Perceived high initial and operating cost
	Lack of knowledge of economic benefits
Technological Limitations (Please check 3 most relevant items from the list below)	Maintaining quality of products made from recovered material
	Lack of modern technologies, facility of storage and Transportation
	Difficulty in integrating various discarded material collectors Challenge in safe return to the biosphere
	Inability to deliver the same quality as virgin products
Organizational policies and issues (Please check 3 most relevant items from the list below)	Unsupportive organizational and Operational policy
	Lack of recycling and reuse facilities of organizations
	Lack of awareness of Industry 4.0
	Limited willingness to collaborate in the value chain

Management issues (Please check 3 most relevant items from the list below)	Insufficient strategy for integration of Industry 4.0
	Lack of waste management
	Poor leadership and management towards CE in SC
	Absence of management commitment and approach for CSSM adoption
Circular Economy framework issues (Please check 3 most relevant items from the list below)	Lack of guidelines for quality of refurbishment products
	Lack of successful business models and frameworks to implement CE in SC
	Other solutions might be more favorable than implementing CE in SC
	The whole SC needs are not included
Culture and Social issues (Please check 3 most relevant items from the list below)	Lack of enthusiasm towards CE in SC
	Lack of pressure from social community
	Deficiency of market mechanisms for waste recovery
	Uncertainty of consumer demand

Respondents Information

Respondents Name	Occupation
Dr. Md. Abdul Mottalib	DAAD Fellow, Germany Post-doc Fellow of Swedish Science Research Council and SIDA, Sweden Post-doc Fellow of Royal Society of Chemistry, England Professor Institute of Leather Engineering and Technology University of Dhaka, Dhaka-1209
Mr. Abdur Rahman	Proprietor, Leather Industries of Bangladesh
Mr. Alamgir Hossain	Proprietor, Island Tannery
Mrs. Sultana Chowdhury	Lecturer, Institute of Leather Engineering and Technology
Mr. Moktadir Rahman	Assistant Professor, Institute of Leather Engineering and Technology

Expert 1 Response:

E1	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17
A1	1	LI	LI	HI	LI	HI	HI	HI	HI	LI	LI	NI	HI	HI	VL	VH	VH
A2	HI	1	VH	LI	LI	VL	NI	VL	LI	HI	NI	HI	VH	LI	HI	VH	LI
A3	VH	LI	1	NI	HI	NI	NI	NI	VH	LI	HI	LI	VH	VH	NI	LI	HI
A4	NI	NI	LI	1	HI	NI	HI	VH	LI	VH	VH	LI	NI	NI	NI	LI	VH
A5	HI	LI	HI	HI	1	LI	VL	NI	VL	LI	HI	NI	HI	VH	LI	HI	VH
A6	HI	NI	NI	HI	LI	1	VH	VH	LI	HI	NI	VH	HI	LI	LI	VH	VH
A7	LI	LI	HI	NI	HI	VH	1	VH	LI	HI	LI	VH	VH	NI	NI	LI	VL
A8	VH	LI	LI	VL	LI	LI	VH	1	VH	HI	VL	LI	NI	MI	LI	LI	LI
A9	VH	LI	LI	HI	VL	HI	VH	HI	1	VH	NI	LI	LI	NI	NI	NI	VL
A10	VH	VH	HI	LI	HI	VH	HI	LI	LI	1	HI	VH	LI	LI	HI	NI	VH
A11	NI	LI	LI	VL	HI	LI	NI	NI	LI	VH	1	LI	VH	VH	HI	LI	HI
A12	VH	LI	LI	HI	LI	HI	LI	VH	LI	NI	NI	1	VH	VH	NI	LI	VL
A13	NL	VH	HI	LI	NL	NL	HI	LI	VH	VH	HI	LI	1	VH	LI	VL	LI
A14	LI	HI	HI	LI	VH	VH	HI	LI	HI	VH	HI	VH	LI	1	VH	NI	LI
A15	HI	LI	HI	NI	HI	VH	LI	HI	VH	LI	VH	LI	NI	NI	1	VH	HI
A16	NI	VH	LI	HI	LI	VH	VH	NI	LI	HI	LI	VH	LI	NI	VH	1	VH
A17	HI	VH	LI	NI	LI	VL	NI	VL	LI	HI	NI	HI	VH	LI	HI	VH	1

Step 1: Transferring the linguistic variables into corresponding TFNs (Sample A1 to A3)

		A1						A2						A3			
A1	[	1.00	1.00	1.00	]		[	0.300	0.500	0.700	]		[	0.300	0.500	0.700	]
A2	[	0.50	0.70	0.90	]		[	1.000	1.000	1.000	]		[	0.700	0.900	1.000	]
A3	[	0.70	0.90	1.00	]		[	0.300	0.500	0.700	]		[	1.000	1.000	1.000	]
A4	[	0.00	0.10	0.30	]		[	0.000	0.100	0.300	]		[	0.300	0.500	0.700	]
A5	[	0.50	0.70	0.90	]		[	0.300	0.500	0.700	]		[	0.500	0.700	0.900	]
A6	[	0.50	0.70	0.90	]		[	0.000	0.100	0.300	]		[	0.000	0.100	0.300	]
A7	[	0.30	0.50	0.70	]		[	0.300	0.500	0.700	]		[	0.500	0.700	0.900	]
A8	[	0.70	0.90	1.00	]		[	0.300	0.500	0.700	]		[	0.300	0.500	0.700	]
A9	[	0.70	0.90	1.00	]		[	0.300	0.500	0.700	]		[	0.300	0.500	0.700	]
A10	[	0.70	0.90	1.00	]		[	0.700	0.900	1.000	]		[	0.500	0.700	0.900	]
A11	[	0.00	0.10	0.30	]		[	0.300	0.500	0.700	]		[	0.300	0.500	0.700	]
A12	[	0.70	0.90	1.00	]		[	0.300	0.500	0.700	]		[	0.300	0.500	0.700	]
A13	[	0.00	0.10	0.30	]		[	0.700	0.900	1.000	]		[	0.500	0.700	0.900	]
A14	[	0.30	0.50	0.70	]		[	0.500	0.700	0.900	]		[	0.500	0.700	0.900	]
A15	[	0.50	0.70	0.90	]		[	0.300	0.500	0.700	]		[	0.500	0.700	0.900	]
A16	[	0.00	0.10	0.30	]		[	0.700	0.900	1.000	]		[	0.300	0.500	0.700	]
A17	[	0.50	0.70	0.90	]		[	0.700	0.900	1.000	]		[	0.300	0.500	0.700	]

Step 2: Normalization (Sample A1 to A3)

Formula: Δ Μαξ−Μιν

Normalization

$$xa_{1ij}^{k} = \left(a_{1ij}^{k} - \min a_{1ij}^{k}\right) \Big/ \Delta_{\min}^{\max}$$
$$xa_{2ij}^{k} = \left(a_{2ij}^{k} - \min a_{2ij}^{k}\right) \Big/ \Delta_{\min}^{\max}$$
$$xa_{3ij}^{k} = \left(a_{3ij}^{k} - \min a_{3ij}^{k}\right) \Big/ \Delta_{\min}^{\max}$$
$$\text{Where } \Delta_{\min}^{\max} = \max r_{ij}^{n} - \min l_{ij}^{n}$$

		A1						**A2**						**A3**			
		xl	xm	xr				xl	xm	xr				xl	xm	xr	
A1	[	1.00	0.90	0.70	]	**1.000**	[	0.300	0.400	0.400	]	**1.000**	[	0.300	0.400	0.400	]
A2	[	0.50	0.60	0.60	]		[	1.000	0.900	0.700	]		[	0.700	0.800	0.700	]
A3	[	0.70	0.80	0.70	]		[	0.300	0.400	0.400	]		[	1.000	0.900	0.700	]
A4	[	0.00	0.00	0.00	]		[	0.000	0.000	0.000	]		[	0.300	0.400	0.400	]
A5	[	0.50	0.60	0.60	]		[	0.300	0.400	0.400	]		[	0.500	0.600	0.600	]
A6	[	0.50	0.60	0.60	]		[	0.000	0.000	0.000	]		[	0.000	0.000	0.000	]
A7	[	0.30	0.40	0.40	]		[	0.300	0.400	0.400	]		[	0.500	0.600	0.600	]
A8	[	0.70	0.80	0.70	]		[	0.300	0.400	0.400	]		[	0.300	0.400	0.400	]
A9	[	0.70	0.80	0.70	]		[	0.300	0.400	0.400	]		[	0.300	0.400	0.400	]
A10	[	0.70	0.80	0.70	]		[	0.700	0.800	0.700	]		[	0.500	0.600	0.600	]
A11	[	0.00	0.00	0.00	]		[	0.300	0.400	0.400	]		[	0.300	0.400	0.400	]
A12	[	0.70	0.80	0.70	]		[	0.300	0.400	0.400	]		[	0.300	0.400	0.400	]
A13	[	0.00	0.00	0.00	]		[	0.700	0.800	0.700	]		[	0.500	0.600	0.600	]
A14	[	0.30	0.40	0.40	]		[	0.500	0.600	0.600	]		[	0.500	0.600	0.600	]
A15	[	0.50	0.60	0.60	]		[	0.300	0.400	0.400	]		[	0.500	0.600	0.600	]
A16	[	0.00	0.00	0.00	]		[	0.700	0.800	0.700	]		[	0.300	0.400	0.400	]
A17	[	0.50	0.60	0.60	]		[	0.700	0.800	0.700	]		[	0.300	0.400	0.400	]

Step 3: Compute right (rs) and left (ls) normalized values (Sample A1 to A3)

Compute right (*rs*) and left (*ls*) normalized values

$$xls_{ij}^{k} = xa_{2ij}^{k} \Big/ \left(1 + xa_{2ij}^{k} - xa_{1ij}^{k}\right)$$
$$xrs_{ij}^{k} = xa_{3ij}^{k} \Big/ \left(1 + xa_{3ij}^{n} - xa_{2ij}^{k}\right)$$

	A1		A2		A3	
	xls	**xrs**	**xls**	**xrs**	**xls**	**xrs**
A1	1.000	0.875	0.364	0.400	0.364	0.400
A2	0.545	0.600	1.000	0.875	0.727	0.778
A3	0.727	0.778	0.364	0.400	1.000	0.875
A4	0.000	0.000	0.000	0.000	0.364	0.400
A5	0.545	0.600	0.364	0.400	0.545	0.600
A6	0.545	0.600	0.000	0.000	0.000	0.000
A7	0.364	0.400	0.364	0.400	0.545	0.600
A8	0.727	0.778	0.364	0.400	0.364	0.400
A9	0.727	0.778	0.364	0.400	0.364	0.400
A10	0.727	0.778	0.727	0.778	0.545	0.600
A11	0.000	0.000	0.364	0.400	0.364	0.400
A12	0.727	0.778	0.364	0.400	0.364	0.400
A13	0.000	0.000	0.727	0.778	0.545	0.600
A14	0.364	0.400	0.545	0.600	0.545	0.600
A15	0.545	0.600	0.364	0.400	0.545	0.600
A16	0.000	0.000	0.727	0.778	0.364	0.400
A17	0.545	0.600	0.727	0.778	0.364	0.400

Step 4: Compute the crisp values (Sample A1 to A3)

$$x_{ij}^{k} = \left[xls_{ij}^{k}\left(1 - xls_{ij}^{k}\right) + xrs_{ij}^{k} \times xrs_{ij}^{n}\right] \Big/ \left(1 - xls_{ij}^{k} + xrs_{ij}^{k}\right)$$

	A1	**A2**	**A3**
	xij	**xij**	**xij**
A1	0.875	0.378	0.378
A2	0.576	0.875	0.765
A3	0.765	0.378	0.875
A4	0.000	0.000	0.378
A5	0.576	0.378	0.576
A6	0.576	0.000	0.000
A7	0.378	0.378	0.576
A8	0.765	0.378	0.378
A9	0.765	0.378	0.378
A10	0.765	0.765	0.576
A11	0.000	0.378	0.378
A12	0.765	0.378	0.378
A13	0.000	0.765	0.576
A14	0.378	0.576	0.576
A15	0.576	0.378	0.576
A16	0.000	0.765	0.378
A17	0.576	0.765	0.378

Step 5: Calculate total normalized crisp values (Sample A1 to A3)

Compute total normalized crisp values:

$$\tilde{\omega}_{ij}^{k} = \min a_{ij}^{n} + x_{ij}^{n} \Delta_{\min}^{\max}$$

	A1	A2	A3
	zij	zij	zij
A1	0.88	0.378	0.378
A2	0.58	0.875	0.765
A3	0.76	0.378	0.875
A4	0.00	0.000	0.378
A5	0.58	0.378	0.576
A6	0.58	0.000	0.000
A7	0.38	0.378	0.576
A8	0.76	0.378	0.378
A9	0.76	0.378	0.378
A10	0.76	0.765	0.576
A11	0.00	0.378	0.378
A12	0.76	0.378	0.378
A13	0.00	0.765	0.576
A14	0.38	0.576	0.576
A15	0.58	0.378	0.576
A16	0.00	0.765	0.378
A17	0.58	0.765	0.378