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Analyzing the Interactions Among the Challenges to Circular Economy Practices

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ABSTRACT The concept of circular economy (CE) significantly lessen the waste and environment pollution. A growing number of articles support the need to consider implementing CE within supply chains. Unfortunately, most corporations have not been successful in pursuing this goal, greatly due to existence of several challenges. Up to now, limited articles have analyzed the challenges to CE practices in the leather sector context. To address this issue, this paper introduces a decision support framework for investigating the interdependencies among challenges to CE practices in the leather industry context using Rough-based Decision-Making Trail and Evaluation Laboratory (Rough DEMATEL) technique. According to the results of the study ''lack of financial support from authorities'' is the most pressing challenge that impede CE implementation. Findings can assist industrial decision-makers to focus on the challenges to CE practices and employ effective strategies and solutions for moving the leather industry towards sustainable development.

INDEX TERMS Circular economy, leather industry, rough set theory, DEMATEL, waste minimization.

I. INTRODUCTION

Rapid industrialization has caused extreme resources utilization, which leads to degradation in resources and pollution in environment [1]. To preserve the environment and create a sustainable production system, an efficient production framework is required [2]. Pressing environmental, social and economic issues including water and air pollution, weak working condition, unemployment and supply risk lead to serious financial and economic instability and imbalance for corporations. One way of remedying this issue is via circular economy (CE) implementation [3]. According to Kirchherr *et al.* [4], an economic network which replaces the 'end-of-lif' concept with reducing, reusing and recycling substances in manufacturing process, with the target of improving the quality of environmental, social and economic dimensions is called CE. When transitioning from linear economy to CE, sustainability and closed-loop cycles should be taken into consideration by companies [5].

In CE context, different resources including metals and minerals are considered for reuse after end of their life, which results in a considerable waste reduction, more resource efficiency and higher competitive economy [6]. The CE concept has been given more focus and consideration among academia and experts. A growing number of business and policy advocacy groups have announced their support and interest towards CE. However, CE implementation is still in the early phases, especially in emerging economy nations [7]. Leather industry can be considered as one of the key industries in emerging economies that seriously requires the attention of CE. Complicated chemical processes are required for producing leather from raw materials. Leather sector is taken into consideration as a polluted industry, since it significantly pollutes the environment and also generates wastes [8].

Eco-friendly leather production processes are essential for decreasing the waste, protecting the environment, and reusing the tannery waste. Since CE contains many potential advantages, it is important for the leather industry to employ CE practices. It can help the industry to lessen its waste and maintain the environment, which aids in achieving its sustainable development goals. Research focused on CE in emerging economies leather sector context can help in identifying the current situation of the sector and formulating effective

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strategies for utilization and implementation of CE practices. Due to existence of several challenges, implementing CE practices in developing countries has become problematic. Hence, this study targets the Bangladeshi leather sector to investigate the interactions among challenges to CE implementation, as an exemplified case of the emerging economies leather industry. The Rough Decision-Making Trail and Evaluation Laboratory (Rough-DEMATEL) is applied to aid this investigation.

The Bangladesh leather sector was selected as the case industry for several reasons. First, the sector is considered as one of the dirtiest industries in the world. This is evident from the heavy use of chemicals for the treatment of raw hides and skins which ends up polluting the air, water and soil. Second, it contributes immensely to Bangladesh foreign exchanges with minimal investment [9]. Third, the leather industry in Bangladesh is emergent and therefore requires initiatives that could help them minimize the negative socio-environmental impacts, which can lead to cost savings via avoidance of fines and reducing the cost of operations via example raw material reuse or reduce. As Moktadir *et al.* [10] has identified the potential challenges to CE practices in the leather industry, it needs further investigation to understand the interactions and interdependencies among the identified challenges to CE practices.

The rough-based DEMATEL was selected to aid this investigation due to its uniqueness and ability to handle relatively less data and uncertainty in group decision problem. Several papers in the literature have employed triangular fuzzy numbers (TFNs) for addressing uncertainty issues in various multi-criteria decision-making (MCDM) problems like Fuzzy-AHP [11] and Fuzzy-ANP [12]. However, compared to rough-based DEMATEL technique, these methods cannot efficiently address the interdependencies as well as interrelationship degree among factors [13]. In addition, the fuzzy set can only express the vague opinion into a fuzzy number for a decision-maker. It does not effectively express the various uncertain opinions and does not integrate them in the group decision-making. Rough numbers, as an effective approach, not only can represent the qualitative or uncertain assessment of decision-makers, but also can retain different opinions among all decision-makers. Considering less information for expert judgments ambiguity, Song and Cao [14] implemented rough set approximation that does not need pre-defined membership functions for extending DEMATEL method, which is called rough-DEMATEL. Specifically, this paper addresses the following objectives:

1) To introduce a decision support framework for assessing the challenges to CE practices within the leather industry context;
2) To investigate the interactions and interdependencies among the challenges to CE practices in the leather industry;
3) To provide insights in the practical application of the research within an emerging economy context (Bangladesh).

This paper offers two main contributions: (1) introduces a multi-criteria framework for evaluating the challenges to CE practices in an emerging economy leather industry context. (2) Rough-DEMATEL technique is used to analysis the interrelationships and interdependencies among the challenges in an empirical setting.

II. LITERATURE REVIEW

This section begins with a review of CE concept. Next sub-sections present CE and the leather industry, and the research gap, respectively. Finally, the last sub-section introduces a decision support framework for assessing the challenges to CE practices.

A. CIRCULAR ECONOMY (CE)

According to a research conducted by Geissdoerfer *et al.* [15] CE is a constructive network in which resources wastes, emissions and flow of energy are diminished through closing energy and substances loops. Based on a study conducted by Korhonen *et al.* [16] CE is an initiative of sustainable development which decreases the societal manufacturing-consumption systems' linear material and energy flow by employing renewable energy flows to linear system. CE can reduce wastes and material utilization by creating value of the products. Linear and closed loop are two categories of value chains. In linear value chain, during the production process and after utilization of final products, many wastes are created which are not employed for remanufacturing, whereas in the context of CE, supply chain wastes are collected from variety of channels and are considered for reuse and remanufacturing [17].

The understanding of CE and its utilization to economic systems has been evolved to integrate variety of concepts which form the closed loop ideas, including cradle-to-cradle [18], ecology laws [19] and looped economy [7]. The CE is an approach that corporations should adopt through involving in activities that reduce/enhance the use/reuse of materials, while certifying that they can be recyclable [20]. Desing *et al.* [21] argued that the concept of CE has been developed to meet the increasing demand without any environmental degradation. Closed-loop resource networks that concentrate on recirculating materials and eliminating wastes, have achieved considerable reputation under CE topic [22].

Geng *et al.* [23] argued that policies and incentives should be improved to deploy and propagate CE practices globally. Buchmann-Duck and Beazley [24] noted that the CE concept is almost new, and the concept has evolved according to similar theories on waste and open and closed economies within the last century. Initially '3R' policy including reuse, reduce and recycle of energy and material utilization were employed for integrating CE factors into supply chains [25], whereas currently '6R' policy including additional recover, redesign and remanufacturing are also taken into consideration [26].

Variety of studies have investigated CE from various categories and contexts to diminish the waste and preserve

the environment. For example, Charef and Emmitt [27] assessed the importance of building information modelling to overcome the barriers towards CE practices. Bag *et al.* [28] proposed a theoretical model to show the importance of technological progress to improve the CE practices. Shayganmehr *et al.* [29] investigated the industry 4.0 enablers for the cleaner production and CE practices in an emerging economy context. Primc *et al.* [30] developed measures of CE configuration and investigated the role of CE practices at various levels of a corporation' progress. Principato *et al.* [31] examined food loss and waste, considering CE concept in the context of Italian pasta supply chains. In the next sub-section of the literature review, CE and the leather industry is overviewed.

B. CE AND THE LEATHER INDUSTRY

CE practices minimize the generation of waste and simplify utilization of used products, hence can prevent pollution of environment [32]. According to a research conducted by Sfez *et al.* [33], CE practices are needed to preserve the environment and have sustainable manufacturing practices. Several authors have studied adoption and implementation of CE practices in the leather sector. For example, Moktadir *et al.* [10] argued that leather sector is taken into consideration as a key polluted industry in emerging economies such as Bangladesh. Since raw hides and skins make major leather industry raw materials, they are transformed to finished leather products using complicated chemical processes, the conversion process extremely pollutes the environment [8]. For minimization of waste and reusing waste of tannery, eco-friendly leather manufacturing system must be occurred. Implementing CE practices in emerging economy nations is complicated, since several challenges exist. Therefore, assessment of challenges and applying effective solutions for dealing with them and diminishing their adverse impact is essential. Assessing challenges to CE practices in the leather supply chain significantly help industrial managers and experts in the leather sector to employ practical policies and solutions to implement CE practices in the leather supply chains [8]. Research gap is determined in the next sub-section.

C. RESEARCH GAP

Kazancoglu *et al.* [5] argued that research focused on CE is immature and needs more investigation, especially in emerging economies such as Bangladesh. Due to large amount of waste production and material consumption, considerable harmful environmental and social impact exist in Bangladesh leather sector, which can be significantly reduced through utilization of CE [10]. Based on the literature review, up to now, studies have not analyzed the interrelationships and interdependencies among challenges to CE practices in emerging economies leather industry context. To address this gap in the literature, this research focuses on analyzing the interdependencies and interactions among challenges to CE practices in an emerging economy leather sector context (Bangladesh). Last sub-section of the literature review introduces a decision support framework for evaluating the challenges to CE practices.

D. A DECISION SUPPORT FRAMEWORK FOR ASSESSING THE CHALLENGES TO CE PRACTICE

Limited studies have introduced a decision support framework for evaluating the challenges to CE practices. This paper uses a decision support framework for evaluating the challenges to CE practices [10] in an emerging economy leather industry. The framework contains eight challenges to CE practices. This paper aims to explore and analysis the interactions and interdependencies among these challenges to CE practices. The framework and detailed explanation of each challenge can be found in Table 1. In the next Section the methods and techniques used in this study are comprehensively described.

III. METHODOLOGY

This section briefly introduces the rough numbers and the steps of DEMATEL analysis. The detailed formulation can be seen in Liou *et al.* [34] and Bai and Sarkis [35].

A. ROUGH NUMBER

Rough set theory (RST) has been proved to be a useful tool to deal with uncertainty, cognitive impact, vagueness information in multiple decision-makers' subjective evaluations context [36]. It is developed based on the logic of RST with original data and does not require any additional information. According to Zhai *et a*l. [37], a RN can be defined as follows

Let $U = \{x_i | i = 1, \ldots, n\}$ be a universe containing n objects. Assume there is a set of K classes of decision maker preferences (e.g. expectations), $R = \{J_k | k = 1, \ldots, K\}$ ordered in a sequence of $J_1 \leq J_2 \leq \ldots \leq J_K$. Then, X is an arbitrary object of U, and then the lower approximation $\underline{Apr}(J_k)$ and the upper approximation $\overline{Apr}(J_k)$ can be defined as follows:

$$\underline{Apr}(J_k) = \cup\{X \in U/R(X) \leq J_k\} \tag{1}$$

$$\overline{Apr}(J_k) = \cup\{X \in U/R(X) \geq J_k\} \tag{2}$$

A judgment element can be presented with by a RN defined with lower limit $\underline{Lim}(J_k)$ and upper limit $\overline{Lim}(J_k)$ as follows

$$\underline{Lim}(J_k) = \frac{\sum R(X)}{M_L} | X \in \underline{Apr}(J_k) \tag{3}$$

$$\overline{Lim}(J_k) = \frac{\sum R(X)}{M_U} | X \in \overline{Apr}(J_k) \tag{4}$$

where M_L and M_U represent the number of objects included in the lower approximation and upper approximation of J_k, respectively. A judgment element J_k can be converted into rough boundary interval $Rn(J_k)$ as

$$Rn(J_k) = [\underline{Lim}(J_k), \overline{Lim}(J_k)] = [J_k^L, J_k^U] \tag{5}$$

where J_k^L and J_k^U represent the lower limit and upper limit of rough number $Rn(J_k)$, respectively. A rough number with a smaller boundary interval is interpreted as more precise one.

TABLE 1. Decision support framework for this research.

Challenges to CE	Code	Description
Lack of technological advancement	B1	Improved technological facility is essential for diminishing waste and remanufacturing. Lack of technological advancement act as a big challenge for to the CE implementation in the leather sector.
Lack of financial supports from authorities	B2	To employ CE policy, it is necessary to expand budget. In the current scenario, the financial facility does not exist in the leather supply chain.
Absence of strong legislation towards CE	B3	Strong legislation facility may drive the industrial experts in the leather sector to apply CE practices to preserve the environment.
Lack of awareness of CE	B4	Proper knowledge on CE implementation and world business trends should be posed by decision-makers in the leather sector.
Lack of communication platforms	B5	Communication between manufacturer, buyer and seller to consumer is important for implementing CE practices. For efficient employing CE practices in the leather sector, it is necessary to develop strong communication platform framework in the supply chains.
Lack of reverse logistics facilities	B6	Because of in CE practices, it is essential to collect used products for reuse. Therefore, without proper reverse logistics facilities, CE implementation is not possible in the leather sector.
Lack of pressure from social community	B7	A noble nation may give pressure to implement CE practices towards environmental sustainability. However, in developing nations, people are not knowledgeable about the CE concept.
Lack of long-term strategic goals	B8	Manufacturers need to focus on developing long-term strategic targets for the leather industry sustainable development.

Source: Moktadir *et al*. [10]

B. DEMATEL MODE

DEMATEL is a popular MCDM model used for determining the dependent criteria and the cause-effect relationships between them. It can help experts better perceive the complicated problem structure, with a quantitative and visual relationship among various criteria through matrices or diagraphs. The specific evaluation process is as follows:

Step 1: Evaluate a pairwise direct-relation matrix Z among criteria among all decision- makers using linguistic variables.

Step 2: Normalize a direct-relation matrix N.

Step 3: Compute a total relation matrix T.

Step 4: Determine the significance of criteria and the cause/effect relationships between them.

Step 5: Visualize the cause/effect diagraph.

A rough number can efficiently avoid uncertain, imprecise and vagueness linguistic judgments. However, when they decide the final priority of factors, they still convert the rough number to the exact number [14]. This conversion process will cause certain data loss. Thus, we introduce the conception of the possibility rate to overcome this gap. The calculation is based on the following definition [38].

Definition: Let $RN(x_1) = (\underline{Lim}(x_1), \overline{Lim}(x_1))$ and $RN(x_2) = (\underline{Lim}(x_2), \overline{Lim}(x_2))$ be two Rough numbers, with $l(RN(x_1)) = \overline{Lim}(x_1) - \underline{Lim}(x_1)$, and $l(RN(x_2)) = \overline{Lim}(x_2) - \underline{Lim}(x_2)$. The possibility rate of $RN(x_1)$ bigger than $RN(x_2)$ can be defined as:

$$P(RN(x_1) > RN(x_2)) = \begin{cases} 1 & \underline{Lim}(x_1) \geq \overline{Lim}(x_2) \\ \dfrac{\overline{Lim}(x_1) - \underline{Lim}(x_2)}{l(RN(x_1)) + l(RN(x_2))} & \overline{Lim}(x_1) > \underline{Lim}(x_2) \wedge \underline{Lim}(x_1) < \overline{Lim}(x_2) \\ 0 & \overline{Lim}(x_1) \leq \underline{Lim}(x_2) \end{cases} \tag{6}$$

IV. PRACTICAL APPLICATION AND ANALYSIS

The focus of this study is to explore the interactions and interdependencies among CE challenges in the Bangladesh leather industry context. The following sub-sections present the background of the involved case companies and the application of rough DEMATEL technique.

A. PROBLEM DESCRIPTION AND BACKGROUND OF EXPERT

In this study, the leather companies from Bangladesh are considered to examine the interrelationships between challenges of CE practices. The leather industry is a key industrial domain of Bangladesh. The recent data of export promotion Bureau (EPB) indicated that in FY2019-20, the leather industry of Bangladesh earned 98.31 million US dollar which is lower than the export performance from the previous fiscal year 2018-2019 [39]. It indicates that the export performance of leather industry is going to be downgraded due to some problems. This industrial segment is facing trouble to expand their export in the recent years, due to improper central effluent treatment plant, absence of proper policy support, lack of sustainable supply chain practices. To sustain in the global competition, this industry needs sustainable and CE practices. However, it is very crucial to implement CE practices, as numerous challenges do exist in the current supply chain network. To understand the existing challenges of CE implementation practices, it needs to understand the interactions, as causal group challenges have significant influence on effect group challenges. Therefore, this study will assist the experts to overcome the challenges by taking initiative to eliminate the causal group challenges. In this paper, six respondents (Leather supply chain experts) from six case firms were considered purposively to understand the actual scenario in the Bangladesh leather sector. Respondents were selected from six leather companies, as they have high interest to understand the interactions among CE challenges. The details of case companies are explained in brief in below:

The case company "A" is the large size leather industry operating production in Savar EPZ. The main product of this case company is finished leather. This case company is also producing wet blue and crust leather based on the buyer demand. The production capacity of this company is around 83 million squar feet of leather per annual. From this case firm, respondent "M1" was selected, as he has 25 years active working experience in leather supply chain. To collect the data, we first communicated with these respondents via telephone call. Due to his strong interest on the research theme, we visited his factory along with a set of questionnaires to collect the data.

The case company "B" is a medium size leather industry located in Savar industrial area. It is one of the export-oriented leather industries which is producing wet blue, crust and finished leather. The production capacity of this case company is approximately 42 million square feet of leather per annual. From this case company, we contacted respondent "M2" to collect the data. The case company "C" is a medium size tannery industry established in Savar EPZ area. This company is well flourished with modern machinery and equipment.

The annual production capacity of this case company is around 32 million square feet of leather. This case company has keen interest on CE practices. Respondent "M3" showed interest in data collection process and participated in our work.

Next case company "D" is a small size tannery industry operating their production activities in the Savar EPZ area. This company exports its wet blue/crust/finished leather to many countries. The annual production rate of this case company is around 23 million square feet of leather. As the global competition is increasing day by day, this company wants to implement CE practices. Therefore, we collected the data from respondent "M4" by visiting the factory location.

The case companies' "E" and "F" are medium and small size leather industry, respectively. Their annual production capacities are 42 and 18 million square feet of leather per annual. These case companies also showed interest to our research. Therefore, the respondents "M5" and "M6" were invited to participate in the data collection. The details of each case company and the experts' profiles are presented in Table 2.

B. APPLICATION OF ROUGH-DEMATEL METHODOLOGY

Our study identifies the internal strength of the potential challenges to CE practices implementation and the external relationship among them using a combined Rough-DEMATEL methodology, with input of six experts in the Bangladesh leather industry. The steps of this analysis are presented as follows:

Step 1: Evaluating the internal strength of each CE challenge for each expert.

Six (d = 6) experts were asked to evaluate the internal strength for each CE challenge $B = \{B_i \,|i = 1, 2, \ldots, n\}$ (n = 8) using linguistic terms. It has a five-point scale of linguistic terms ranging from 0 (No Strength) to 5 (Very High Strength) for each CE challenge and defined in Table 3. A matrix $S = [s_i^d]$ is obtained for all experts. s_i^d describes linguistic judgments of expert d for the internal strength of CE challenge i.

In our case, Expert-1 thinks that "Lack of technological advancement (B1)" has Very High Strength, and then s_1^1 will be assigned a value "VHS or 5". Therefore, the internal strength matrix $S = [s_i^d]$ is developed and shown in Table 4.

Step 2: Aggregating a rough internal strength of CE challenges.

For manipulating the imprecise, subjective, and vague linguistic decision-making information, this step converts evaluation of crisp numbers s_i^d into rough number $Rn(s_i^*)$ for all experts according to Eqs. (1) - (5). In our case, six experts evaluate the "Lack of technological advancement (B1)" with linguistic judgments {VHS, HS, HS, VHS, HS, MS} or {5, 4, 4, 5, 4, 3}. Then, s_1^d is converted into the rough internal strength as follow:

TABLE 2. List of the decision-makers involved in the study.

Case companies with their production rate	Experts' designation	Role in production	Job Experience
A (83 million square feet per annual)	Chief leather technologist (M1)	Leather processing and quality assurance	25 years
B (42 million square feet per annual)	Leather technologist (M2)	Leather finishing	14 years
C (32 million square feet per annual)	Chief leather technologist (M3)	Quality assurance in crust department	18 years
D (23 million square feet per annual)	Leather technologist (M4)	Production of quality finished leather	13 years
E (42 million square feet per annual)	Leather chemist (M5)	Ensure quality recipe	15 years
F (18 million square feet per annual)	Leather technologist (M6)	Quality assurance in wet blue section	19 years

TABLE 3. Linguistic terms and corresponding rating values.

Linguistic Terms		Rating value
Internal strength	Direct relationship	
Very High Strength (VHS)	Very High Influence (VHI)	5
High Strength (HS)	High Influence (HI)	4
Medium Strength (MS)	Medium Influence (MI)	3
Low Strength (LS)	Low Influence (LI)	2
Very Low Strength (VLS)	Very Low Influence (VLI)	1
No Strength (NS)	No Influence (NI)	0

TABLE 4. Internal strength of challenges to CE assessed by experts.

Challenges	Expert1	Expert2	Expert3	Expert4	Expert5	Expert6
(B1)	VHS	HS	HS	VHS	HS	MS
(B2)	HS	VHS	VHS	HS	VHS	MS
(B3)	HS	HS	LS	MS	VLS	VHS
(B4)	LS	VLS	LS	MS	HS	MS
(B5)	MS	MS	HS	MS	MS	HS
(B6)	HS	HS	VHS	MS	MS	HS
(B7)	MS	LS	MS	VLS	HS	HS
(B8)	HS	VHS	HS	HS	MS	VLS

First,

$$\underline{Lim}(1) = 0,\ \underline{Lim}(2) = 0,\ \underline{Lim}(3) = \frac{3}{1} = 3,$$
$$\underline{Lim}(4) = \frac{3+4+4+4}{4} = 3.75,$$
$$\underline{Lim}(5) = \frac{3+4+4+4+5+5}{6} = 4.17$$

and

$$\overline{Lim}(1) = \frac{3+4+4+4+5+5}{6} = 4.17,$$
$$\overline{Lim}(2) = \frac{3+4+4+4+5+5}{6} = 4.17,$$
$$\overline{Lim}(3) = \frac{3+4+4+4+5+5}{6} = 4.17,$$

TABLE 5. Aggregated rough internal strength of challenges to CE.

Challenges	Rough Number
(B1)	[3.64,4.38]
(B2)	[3.67,4.52]
(B3)	[2.09,4.02]
(B4)	[1.97,3.16]
(B5)	[3.22,3.5]
(B6)	[3.48,4.15]
(B7)	[2.08,3.38]
(B8)	[2.14,4.15]

$$\overline{Lim}(4) = \frac{4+4+4+5+5}{5} = 4.4,$$
$$\overline{Lim}(5) = \frac{5+5}{2} = 5.$$

Second, $s_1^L = (\underline{Lim}(3) + \underline{Lim}(4) + \underline{Lim}(5))/3 = 3.64$, and $s_1^U = (\overline{Lim}(1) + \overline{Lim}(2) + \overline{Lim}(3) + \overline{Lim}(4) + \overline{Lim}(5))/5 = 4.38$. Third, $Rn(s_1^*) = [s_1^L, s_1^U] = [3.64, 4.38]$. The other rough internal strength of CE challenges can be obtained similarly. Finally, the aggregated rough internal strength of CE challenges can be obtained in Table 5.

***Step* 3**: Developing a pairwise direct-relation matrix for each manager.

Six ($d = 6$) experts were also invited to evaluate the degree for each of the influence relationship between CE challenges $B = \{B_i \,|i = 1, 2, \ldots, n\}$ ($n = 8$). We also use a five-point scale of linguistic terms ranging from 0 (No Influence) to 5 (Very High Influence) for pair-wise comparisons that defined in Table 3. A pairwise direct-relation matrix $Z^d = [z_{ij}^d]_{8\times 8}$ is obtained for each expert d. z_{ij}^d describes linguistic judgments of expert d for the influence of CE challenge i on CE challenge j.

In our case, Expert-1 thinks that "Lack of technological advancement (B1)" has medium influence "Lack of financial supports from authorities (B2)", and then z_{12}^1 will be assigned a value "MI or 3". Hence, the six direct-relation matrix $Z^d (d = 1, \ldots, 6)$ is developed and shown in Table 6.

***Step*4**: Integrating the rough direct-relation matrix

This step is mainly divided into two sub-steps.

Sub-step 1: Aggregating a sequence direct-relation matrix $Z^* = [z_{ij}^*]_{8\times 8}$ based on the all response direct-relation matrices Z^d. $z_{ij}^* = \{z_{ij}^{1*}, z_{ij}^{2*}, \ldots, z_{ij}^{d*}\}$ denotes the sequence $z_{ij}^{1*} \le z_{ij}^{2*} \le \ldots \le z_{ij}^{d*}$ used to describe the influence of CE challenge i on CE challenge j.

Sub-step 2: Converting the sequence direct-relation matrix into rough direct-relation matrix.

In our case, from the sequence direct-relation matrix, $z_{12}^* = \{1, 2, 2, 3, 3, 3\}$ with six elements. The corresponding rough number is generated $Rn(z_{12}^*) = [1.67, 2.64]$. Hence, a rough direct-relation matrix is developed and shown in Table 7.

***Step*5**: Identifying the normalized rough direct-relation matrix.

In our case, we found $Rn(z_{1j}^*) = [0, 0]$, [1.67,2.64], [2.67,3.64], [1.64,2.52], [2.84,4.16], [3.23,4.33], [2.21,4.1], [2.28,4.04] for $j = 1, \ldots, 8$. Next, we sum the upper bounds of rough values for each row i as $\sum_{j=1}^{n} \overline{Lim}(z_{ij}^*) = 0 + 2.64 + 3.64+2.52+4.16+4.33+4.10+4.04 = 25.44$. Same process was applied to each column j. Then, we select the maximum sum (s = 31.33) for all i and j.

Finally, the normalized rough direct-relation matrix was obtained by divided s.

***Step*6**: Computing the rough total relation matrix.

We first separate a normalized rough direct-relation matrix RN into two sub-matrices: a lower limit matrix $\underline{RN}$ and an upper limit matrix $\overline{RN}$. Then we can aggregate two rough total relation matrixes ($\underline{RT}$ and $\overline{RT}$) into a rough total relation matrix ($RT = [\underline{RT}, \overline{RT}]$), as shown in Table 8.

***Step*7**: Determining row ($Rn(R_i)$) and column ($Rn(D_j)$).

The values $Rn(R_i)$ represent the sum of direct and indirect rough influence by CE challenge B_i on the other CE challenges.

The values $Rn(D_j)$ shows the sum of direct and indirect rough influence that CE challenge B_j is receiving from the other CE challenges. We obtain row ($Rn(R_i)$) and column ($Rn(D_j)$) by sum row s and column s of the rough total relation matrix.

***Step*8**: Determining the overall prominence ($Rn(P_i)$) and net effect ($Rn(E_i)$).

The values $Rn(P_i)$ show the index representing the total cause and effect. The larger the value of $Rn(P_i)$ the greater the overall prominence (importance) of CE challenge B_i. The values $Rn(E_i)$ show the net effect or cause of CE challenge B_j. The results for six experts are shown in Table 9. The prominence $Rn(P_i)$ shows how important a CE challenge i relative to the available set of CE challenges, whereas the net effect $Rn(E_i)$ will divide the CE challenges into cause-and-effect groups. If $(\frac{\underline{Lim}(E_i)+\overline{Lim}(E_i)}{2}) > 0$ then CE challenge i is a net cause, or foundation, for other CE challenges. If $(\frac{\underline{Lim}(E_i)+\overline{Lim}(E_i)}{2}) < 0$ then CE challenge i is net effect of other CE challenges.

***Step* 9**: Developing an impact-relation map.

This step is mainly divided into four sub-steps.

Sub-step 1: Marking the CE challenges in the impact-relation map. Based on the average prominence and net effect values obtained in Step 8, an impact-relation map for each CE challenge can be plotted onto a two-dimensional axis (P_i, E_i). It can provide valuable and visualized insights for critical CE challenge identification. Figure 1 shows a map of the overall aggregated CE challenges prominence and net effect results.

Sub-step 2: Identifying the threshold value (θ) to observe general relationships amongst all the CE challenges simultaneously. It is necessary to develop relationship digraph to identify most influential relationships of CE challenges that are over a threshold value θ. It can be calculated by taking the

TABLE 6. Direct relationships between challenges to CE constructed by all experts.

Challenges	B1	B2	B3	B4	B5	B6	B7	B8	B1	B2	B3	B4	B5	B6	B7	B8
	Expert-1								Expert-2							
B1	NI	MI	MI	VLI	MI	MI	VLI	MI	NI	MI	LI	LI	LI	HI	HI	VHI
B2	HI	NI	VHI	LI	VHI	HI	MI	MI	VHI	NI	VHI	HI	VHI	HI	MI	HI
B3	VLI	LI	NI	HI	LI	MI	LI	HI	VHI	LI	NI	LI	HI	LI	LI	VHI
B4	LI	VLI	LI	NI	HI	VLI	MI	HI	VLI	MI	HI	NI	MI	HI	MI	VHI
B5	HI	MI	LI	LI	NI	MI	MI	LI	VHI	HI	VHI	LI	NI	LI	MI	HI
B6	HI	VLI	MI	HI	LI	NI	HI	LI	HI	LI	HI	VLI	LI	NI	VHI	MI
B7	HI	MI	LI	MI	VLI	HI	NI	HI	HI	LI	VLI	LI	LI	MI	NI	MI
B8	LI	VHI	HI	VHI	VHI	MI	LI	NI	LI	VHI	VHI	VLI	MI	HI	MI	NI
	Expert-3								Expert-4							
B1	NI	LI	HI	MI	VHI	MI	HI	VLI	NI	LI	MI	LI	HI	MI	VHI	MI
B2	HI	NI	VHI	VHI	MI	VHI	LI	HI	MI	NI	VHI	MI	VHI	MI	MI	HI
B3	HI	VLI	NI	MI	VHI	VLI	HI	HI	VLI	VHI	NI	MI	HI	VHI	HI	MI
B4	HI	VHI	MI	NI	VLI	HI	MI	LI	VHI	HI	VLI	NI	HI	MI	HI	VLI
B5	LI	LI	MI	VLI	NI	HI	HI	LI	VHI	VHI	HI	LI	NI	LI	HI	MI
B6	HI	MI	VLI	VHI	LI	NI	MI	MI	LI	MI	VLI	MI	LI	NI	VHI	VLI
B7	HI	LI	LI	VHI	LI	VHI	NI	HI	VLI	MI	VHI	MI	HI	LI	NI	LI
B8	HI	MI	LI	HI	VHI	HI	VHI	NI	HI	VHI	MI	VHI	LI	MI	HI	NI
	Expert-5								Expert-6							
B1	NI	VLI	HI	MI	MI	MI	LI	VHI	NI	MI	HI	LI	HI	VHI	HI	MI
B2	MI	NI	HI	VHI	VHI	HI	VHI	VHI	VHI	NI	VHI	HI	MI	HI	VHI	MI
B3	MI	MI	NI	LI	LI	MI	VLI	VLI	MI	HI	NI	MI	LI	LI	HI	MI
B4	VHI	HI	VHI	NI	HI	LI	VHI	VHI	MI	HI	VLI	NI	MI	MI	HI	HI
B5	HI	VHI	VLI	MI	NI	MI	VLI	HI	MI	VHI	HI	VHI	NI	VHI	VHI	LI
B6	MI	HI	MI	VHI	LI	NI	HI	HI	HI	LI	LI	LI	VHI	NI	HI	VHI
B7	LI	HI	LI	MI	VHI	MI	NI	LI	LI	MI	HI	MI	VHI	VHI	NI	HI
B8	LI	HI	MI	VHI	HI	VHI	LI	NI	HI	VHI	MI	HI	VHI	VHI	LI	NI

TABLE 7. Rough direct relationships between challenges to CE.

Challenges	B1	B2	B3	B4	B5	B6	B7	B8
B1	[0,0]	[1.67,2.64]	[2.67,3.64]	[1.64,2.52]	[2.84,4.16]	[3.23,4.33]	[2.21,4.1]	[2.28,4.04]
B2	[3.5,4.5]	[0,0]	[4.42,4.92]	[2.9,4.38]	[3.67,4.67]	[3.6,4.4]	[2.75,4.1]	[3.48,4.36]
B3	[2.06,4.02]	[1.98,3.91]	[0,0]	[2.48,3.36]	[2.66,4.17]	[1.88,3.58]	[1.83,3.34]	[2.42,4.12]
B4	[2.07,4.21]	[2.43,4.19]	[1.79,3.93]	[0,0]	[2.17,3.59]	[1.9,3.38]	[3.36,4.33]	[2.19,4.25]
B5	[2.9,4.38]	[2.88,4.54]	[2.09,4.02]	[1.81,3.58]	[0,0]	[2.62,4.1]	[2.42,4.12]	[2.36,3.5]
B6	[2.67,3.77]	[1.84,3.16]	[1.67,3.17]	[2.07,4.21]	[2.25,3.75]	[0,0]	[3.64,4.52]	[2.07,3.93]
B7	[1.83,3.34]	[2.48,3.36]	[1.9,3.79]	[2.66,3.86]	[2.02,4.11]	[2.83,4.33]	[0,0]	[2.5,3.64]
B8	[2.5,3.5]	[3.67,4.77]	[2.77,4.11]	[2.67,4.53]	[2.88,4.54]	[3.5,4.5]	[2.46,4.13]	[0,0]

TABLE 8. Rough total-relation between challenges to CE.

Challenges	B1	B2	B3	B4	B5	B6	B7	B8
B1	[0.09,0.81]	[0.14,0.86]	[0.17,0.91]	[0.13,0.85]	[0.18,0.96]	[0.19,0.96]	[0.16,0.95]	[0.16,0.92]
B2	[0.23,1.1]	[0.12,0.94]	[0.25,1.11]	[0.2,1.06]	[0.24,1.15]	[0.25,1.13]	[0.22,1.12]	[0.23,1.1]
B3	[0.15,0.96]	[0.14,0.92]	[0.08,0.84]	[0.15,0.91]	[0.17,1]	[0.15,0.97]	[0.14,0.97]	[0.15,0.96]
B4	[0.15,1]	[0.16,0.97]	[0.14,0.99]	[0.08,0.85]	[0.16,1.02]	[0.15,1.01]	[0.19,1.03]	[0.15,1]
B5	[0.18,1.01]	[0.17,0.98]	[0.16,1]	[0.14,0.96]	[0.1,0.93]	[0.18,1.03]	[0.17,1.03]	[0.16,0.99]
B6	[0.17,0.95]	[0.14,0.9]	[0.14,0.93]	[0.14,0.92]	[0.16,0.98]	[0.1,0.87]	[0.2,0.99]	[0.15,0.95]
B7	[0.14,0.94]	[0.16,0.91]	[0.14,0.94]	[0.16,0.91]	[0.15,0.99]	[0.18,0.99]	[0.1,0.86]	[0.16,0.95]
B8	[0.19,1.05]	[0.21,1.04]	[0.19,1.06]	[0.18,1.03]	[0.2,1.11]	[0.22,1.1]	[0.19,1.09]	[0.11,0.95]

TABLE 9. Degree of prominence and net cause / effect of challenges.

Challenges	Prominence P_i	Net Effect E_i	(P_i, E_i)	Impact
(B1)	[2.5,15.02]	[-6.6,5.92]	[8.76, -0.34]	Effect
(B2)	[2.98,16.22]	[-5.78,7.46]	[9.60, 0.84]	Cause
(B3)	[2.4,15.29]	[-6.63,6.25]	[8.85, -0.19]	Effect
(B4)	[2.38,15.35]	[-6.31,6.67]	[8.87, 0.18]	Cause
(B5)	[2.62,16.07]	[-6.86,6.59]	[9.35, -0.14]	Effect
(B6)	[2.62,15.55]	[-6.86,6.07]	[9.09,-0.40]	Effect
(B7)	[2.57,15.53]	[-6.84,6.11]	[9.05, -0.37]	Effect
(B8)	[2.77,16.26]	[-6.34,7.15]	[9.52, 0.41]	Cause

TABLE 10. Dominance probability rate matrix among challenges.

Challenges	B1	B2	B3	B4	B5	B6	B7	B8	B1	B2	B3	B4	B5	B6	B7	B8
	Internal strength (%)								Direct relationship (%)							
B1	50	46	69	80	98	59	76	50	50	47	50	50	48	49	49	47
B2	54	50	71	82	100	63	79	54	53	50	53	53	51	52	52	50
B3	31	29	50	59	61	38	55	31	50	47	50	50	48	49	49	47
B4	20	18	41	50	47	26	45	20	50	47	50	50	48	49	49	48
B5	2.0	0.0	38	53	50	14	45	2.0	52	49	52	52	50	51	51	49
B6	41	37	62	74	86	50	69	41	51	48	51	50	49	50	50	48
B7	24	21	45	55	55	31	50	24	51	48	51	51	49	50	50	48
B8	50	46	69	80	98	59	76	50	53	50	53	52	51	52	52	50

mean $[\underline{Lim}(\overline{t_{ij}}), \overline{Lim}(\overline{t_{ij}})]$ and standard deviation σ of the total relation matrix ($\theta = [0.200, 1.055]$).

Sub-step 3: Identifying the most influential relationships in the total relation matrix. To compare the size of two rough numbers, we now develop the dominance possibility rate based on Eq. (6).

We compare every $RN(t_{ij})$ with the threshold value θ, and then establish a dominance matrix. For example, if the total relation value is $RN(t_{12}) = (0.089, 0.808)$, then the possibility rate measure that $RN(t_{12})$ is better than the threshold value θ is given by $p(RN(t_{12}) > \theta) = \frac{0.808-0.200}{0.808-0.089+1.055-0.200} = 38.60\%$.

Sub-step 4: Graphically describing the interrelationships between CE challenges. All the most influential relationships that meet or exceed the threshold value θ are indicated. We then plot the relationship diagram in the Figure 1.

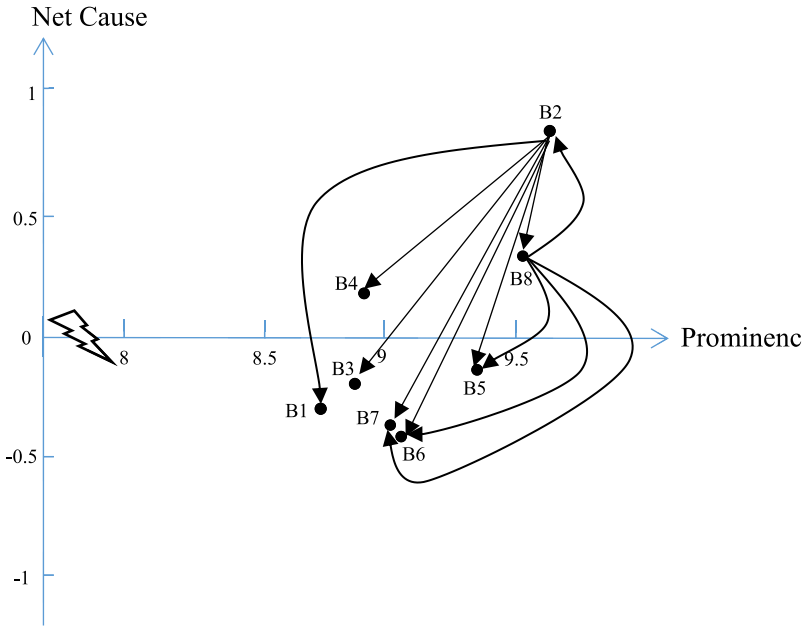

FIGURE 1. Overall prominence-causal relationship diagram.

TABLE 11. Ranking of challenges to CE practices.

Challenges	Direct relationship	Rank	Internal strength	Rank
(B1)	[2.5,15.02]	8	[3.64,4.38]	2
(B2)	[2.98,16.22]	1	[3.67,4.52]	1
(B3)	[2.4,15.29]	7	[2.09,4.02]	6
(B4)	[2.38,15.35]	6	[1.97,3.16]	8
(B5)	[2.62,16.07]	3	[3.22,3.5]	4
(B6)	[2.62,15.55]	4	[3.48,4.15]	3
(B7)	[2.57,15.53]	5	[2.08,3.38]	7
(B8)	[2.77,16.26]	2	[2.14,4.15]	5

Step 10: Ranking the internal strength and direct relationship of all CE challenges

In this step, we compare every $RN(s_j^*)$ or $RN(P_i)$ with each other, and then establish two dominance matrixes: internal strength and direct relationship. The complete dominance matrix is shown in Table 10 and the ranking results can be found in Table 11.

V. DISCUSSION

The ranking of CE challenges based on prominence (Pi) in Table 9 can be sorted as B2 > B8 > B5 > B6 > B7 > B4 > B3 > B1. The higher value of (Pi) indicates the stronger contribution to hinder the successfully implementing leather sector CE practices. According to values of Pi, it is clear that the prominence of CE challenge ''Lack of financial supports from authorities (B2)'' received the top rank in the analysis. Therefore, the stronger challenge to implement CE in the leather sector will be ''Lack of financial supports from authorities (B2)'' as CE implementation needs huge amount of investment to set the eco-friendly process and policies. It can hamper the implementation process as this CE challenge has stronger co-relation with other CE challenges. Therefore, decision-makers should be serious on it to eliminate this challenge by taking proper strategic policies and involvement of top authority to facilitate the financial incentives.

The challenge ''Lack of long-term strategic goals (B8)'' received the second most critical challenge for properly implementation of CE practices. It is very crucial that this challenge can hamper the total implementation process as without long-term strategic goals. Next, the CE challenges are ''Lack of communication platforms (B5)'', ''Lack of reverse logistics facilities (B6)'', ''Lack of pressure from social community (B7)'', ''Lack of awareness of CE (B4)'', ''Absence

of strong legislation toward CE (B3)'', ''Lack of technological advancement (B1)'' are received the third, fourth, fifth, sixth seventh and eighth position consequently. The following sub-sections discuss about the interrelation among the CE challenges.

A. CAUSE GROUP CHALLENGES

Based on the average prominence and net effect values from Table 9, an impact-relation map for each CE challenge is plotted (Figure 1) into a two-dimensional axis (Pi, Ei). If the value of the average net effect comes to be greater than zero, the CE challenge will be listed in the causal group. Therefore, the analysis indicated that the three CE challenges 'Lack of financial supports from authorities (B2)', 'Lack of long-term strategic goals (B8)', and 'Lack of awareness of CE (B4)' were identified as the causal challenges. These CE challenge have strong effect in other CE challenges. In a developing country like Bangladesh, to employ CE practices in the leather sector, it requires huge investment to modify the supply chain network considering eco-friendly production. Thus, financial support may act as critical success factors for the leather industry towards CE practices.

The leather industry is a complex industrial domain, and it needs lots of chemical, mechanical, and physical treatments. As the processes involved in the leather manufacturing are largely related to chemical operations. Therefore, huge amount of tannery effluent can be generated which can hamper the environment drastically. Hence, to make the supply chain eco-friendlier, it needs to redesign the whole network. To redesign the existing supply chain network, it needs huge amount of investment. However, it is very tough to get financial support to do this as it has no direct financial benefits, rather it will need investment and efforts with uncertainty of turnover. Therefore, the owners of leather industry do not like to implement CE practices. The previous studies also mentioned that the lack of financial facility is a crucial challenge for the CE implementation without showing any interactions between the CE challenges [10].

Lack of long-term strategic goals (B8) was identified as the second critical causal CE challenge. Without lack of long-term strategic goals, it is difficult to implement CE practices in the leather sector. Currently, leather sector of Bangladesh is facing huge trouble to operate their traditional business as they are not able to produce eco-friendly leather due to absence of center effluent treatment plant that is why they are unable to exports the leather in the developed country. To export the leather, it is mandatory for the leather manufacturers to maintain the compliance issue. However, to make the leather supply chain more sustainable, the leather sector should have long-term strategic goals with strong coordination among the supply chain partners. Currently, they have no proper long-term strategic goals. Therefore, current condition indicates that the Lack of long-term strategic goals challenge is responsible to hamper the CE implementation. The decision-makers should be careful to quickly form some long-term strategic goals for leather industry along with coordination facility among all parties involved in the leather supply chain.

Lastly, the challenge 'Lack of awareness of CE (B4)' came under causal CE challenge and it is in the bottom of the ranking. However, it has huge impact on effect group challenges. Unfortunately, in Bangladesh, most of the leather manufacturers and consumers are not conscious on CE practices. The manufacturers are processing raw hides and skins without considering CE issues as they are not knowledgeable on CE practices. Therefore, this challenge is one of the important causal challenges which is hindering the implementation process. To implement CE practices, proper knowledge on CE practices can motivate the manufacturers and consumers to use eco-friendly products/green products. Therefore, improving this challenge can significantly eliminate the effect group challenges. Hence, the decision-makers should give more focus on knowledge of CE practices by offering conference and seminar on CE issues.

B. EFFECT GROUP CHALLENGES

If the value of the average net effect comes to be less than zero, then the CE challenge will be listed as the effect group challenge. The findings revealed that the ranking of the effect group CE challenges can be sorted as follows: Lack of communication platforms (B5) > Absence of strong legislation toward CE (B3) > Lack of technological advancement (B1) > Lack of pressure from social community (B7) > Lack of reverse logistics facilities (B6). These five CE challenges can be influenced by the three causal CE challenges greatly. Therefore, decision-makers can give special care to address the causal CE challenges which can help to eliminate the effect group challenges before or during the CE implementation process.

The findings indicated that the CE challenge 'Lack of communication platforms (B5)' received the first position in the effect group challenges. Therefore, this challenge can be less influenced by the causal challenges rather it will act as causal challenge. The CE practices needs strong communication platform to collaborate with all parties involved in the supply chain. Without good platform of communication, it will be very complex to implement the CE practices. In Bangladesh, especially in the leather supply chain, there is no collaborative supply chain platform that can help to integrate all activities for the betterment of supply chain. Therefore, the leather industry experts gave importance on it during the data collection process. This challenge can be eradicated by developing and implementing the enterprise resource planning (ERP) like communication platform. Offering more funds from the authorities can help to develop or implement ERP in the manufacturing process. This finding can help leather industry experts to eliminate this challenge by taking necessary action plans including some active, reactive, and proactive policies. Next the challenge 'Absence of strong legislation toward CE (B3)' received the second position in the effect group. Strong legislation can be forced the supply chain partners to follow the eco-friendly production practices. As CE practices need

more funds, industry owners do not want to implement the CE practices, rather they are polluting the environment without considering environmental issues. Therefore, strong legislation can act as a great driving fuel. The challenges 'Lack of technological advancement (B1)' and 'Lack of pressure from social community (B7)' received the third and fourth position in the effect group. The CE practices require to install the latest technological device to faster the process and for its better output. However, lack of technological advancement for leather processing industry is a big challenge. Leather processing is largely depending on the various mechanical devices. Therefore, the latest advanced technological devices can help to achieve the eco-friendly production as well as can help to achieve resource efficiency. In the perspective of leather industry of Bangladesh, most of the leather industry far behind the implementation of CE practices. Also, there is a problem with availability of technological device in developing countries. Therefore, the funding facility and the strategic policy can help to influence this challenge greatly. Lack of community pressure is another critical challenge for implementing CE in leather industry. The local consumers are not conscious on eco-friendly products. Therefore, they are also not conscious on eco-friendly leather production and the leather products they are used. If the communities are aware on environment and eco-friendly products, industry owners would be forced to implement CE practices.

Finally, the CE challenge, 'Lack of reverse logistics facilities (B4)' was identified as the effect group challenge. CE practices need to incorporate the reverse logistics facility for waste reduction and to make the environment pollution free. Currently, no leather industry is practicing reverse logistics in Bangladesh. Reverse logistics facility can help to minimize the waste by utilizing the waste through recovery process. The causal group challenges may help to eradicate this challenge by facilitating more funds and awareness on CE.

C. CORRELATION AMONG CHALLENGES

According to Figure 1, critical relationships between challenges are as follows:
(B2)$\longrightarrow$(B1), (B2)$\longrightarrow$(B3), (B2)$\longrightarrow$(B4), (B2)$\longrightarrow$(B5), (B2)$\longrightarrow$(B6), (B2)$\longrightarrow$(B7), (B8)$\longrightarrow$(B7), (B2)$\longleftrightarrow$(B8), (B8)$\longrightarrow$(B5), (B8)$\longrightarrow$(B6). The one-way relationship indicates that the interrelated CE challenge can influence other CE challenge. Therefore, if the authorities take initiative to eliminate the interrelated CE challenge, then the other CE challenge will be eliminated simultaneously. For example, if the interrelated CE challenge 'Lack of financial supports from authorities (B2)' is eradicated from the system then the other challenge 'Lack of technological advancement (B1)' will be eliminated from the system automatically. Both way relationship indicates that both CE challenges can influence each other. Therefore, improvement of one challenge may influence to improve the other one. In this study we got one both way interrelationship between challenges'Lack of financial supports from authorities (B2)' and'Lack of long-term strategic goals (B8)'. Therefore, decision-makers should be sincerer to understand each of the potential CE challenges and their interrelationships to eradicate them from the supply chain for successful implementation of CE practices in the leather supply chain.

VI. CONCLUSION

Utilization of CE practices can decrease the waste, preserve the environment, and help companies achieve their sustainability targets. This study is the first research paper that investigates the interdependencies and interactions among the challenges to CE practices in an emerging economy nation leather sector context (Bangladesh) using rough-DEMATEL methodology, which highlights the novelty of this research. Based on the rough-DEMATEL results, three challenges including 'Lack of financial supports from authorities (B2)', 'Lack of long-term strategic goals (B8)', and 'Lack of awareness of CE (B4)' were identified as the causal challenges for employing CE. Since these three challenges have considerable impact on other challenges, by addressing these challenges, the effect group challenges can be significantly diminished and the whole system can be considerably improved for implementing CE practices. Now leather industry experts in emerging economies have a means to better understand and focus on challenges to CE practices and move their industry towards sustainable development, which highlights the practical contribution of this paper.

Every paper has several limitations, and this research is no exception. Limitations can provide additional room for further research in this area. The first limitation is that a limited number of challenges were taken into consideration in the decision framework. Another limitation is that a limited number of managers and corporations took part in the assessment and completed the data collection. Future researchers could investigate the interdependencies among challenges to CE practices in other countries and discuss the outcome. Possible future studies can identify the challenges to CE practices in other industries and discuss the similarities and differences with the decision framework proposed in this article. In addition, future authors could focus on findings of this article and try to develop efficient policies and solutions to assist the Bangladesh leather sector. We suggest future articles employ other methods such as Total Interpretive Structural Modeling (TISM) for investigating the interrelationships among the challenges to CE practices and use Z or grey numbers for handling the uncertainty issues. Obviously, this research topic is still in the initial phases and needs more investigation and managerial focus, particularly in emerging economies.

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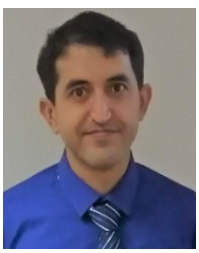

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