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A Study in the Electronics Industry in Bangladesh Using Grey Decision-Making Trial and Evaluation Laboratory (DEMATEL) Method for Obtaining Sustainability in Supply Chain Management

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ABSTRACT

Sustainability has long been seen as a significant organizational concept that aids businesses in achieving competitive advantage and creating value in the society by minimizing environmental risk and effect while improving the environmental, financial, and social achievements of their supply chains. The current study identifies the Critical Success Factors (CSFs) for adopting Sustainable Supply Chain Management (SSCM) in an emerging economy's electronics industry. With the help of twelve industrial experts from two electronic industries and based on literature review, total 20 CSFs were selected for implementing Sustainable Supply Chain Management (SSCM) in Bangladesh. And from those 20 CSFs, 10 final CSFs were selected through Pareto analysis. The methodology of this study based on Grey Decision-Making Trial and Evaluation Laboratory (DEMATEL) has been applied to envisage the organization of the interrelationships among the identified CSFs. While this study can serve as a reference for managers, practitioners, and administrations in the electronics industry to embrace and oversee the ideas of sustainability and make strategic and technical decisions to apply SSCM in Bangladesh's electronics businesses. The factors which has been found out with the greatest influence in this paper are health & safety, hazardous materials, corporate social responsibilities (CSR), and training & education, as determined by the results and findings.

Keywords: Critical success factors, Social achievements, Sustainable, Supply chain management

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1. INTRODUCTION

It is widely recognized that supply chain management (SCM), which is the proactive management of supply chain activities in order to maximize customer value and generate a sustainable competitive advantage, is a critical component of any organization or business. Suppliers, manufacturing plants, warehouses, distribution centers, retail outlets, and customers are the building blocks of a company's supply chain, which is comprised of the following elements: i) maintain gains in environmental, social, and financial performance, ii) excellent management and monitoring throughout supply chain network, iii) improve supply chain sustainability. Sustainability refers to the long-term viability of human life achieved by carefully balancing social, economic, and environmental capital in an ever-changing

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world. In supply chain management, the term sustainable development refers to the long-term viability of human life achieved by carefully balancing social, economic, and environmental capital in an ever-changing world. In recent years, supply chain management has been primarily concerned with a responsive and efficient system of manufacturing and distribution from the raw material stage to the final state of a component. In its most basic form, Sustainable Supply Chain Management (SSCM) is concerned with the creation, maintenance, and growth of long-term environmental, social, and financial value for all stakeholders. These stakeholders include innovators, customers, regulatory agencies, and non-governmental organizations, among others. Diverse stakeholders are avidly evaluating industrial supply chains in order to determine their key success factors (CSFs), which include criteria such as cost, quality, delivery, and emissions, among others (Klassen & Vereecke, 2012; Chen & Chai, 2010). In addition, they investigate their interdependent relationship with the goal of developing ways to a green and sustainable supply chain. The concept of SSCM provides industries with a competitive advantage, particularly in terms of success or failure, by bringing together the innovative ideas of a company. SSCM broadens the conventional definition of Supply Chain Management (SCM) by incorporating environmental, social, and ethical considerations into the mix (Wittstruck & Teuteberg, 2012). Industrial organizations benefit in a variety of ways from the implementation of sustainable supply chain management. Small and medium-sized enterprises (SMEs) rely on SSCM to maintain their long-term survival and competitiveness, as businesses are increasingly judged on their commitment to inclusive, equitable, and sustainable sector growth. Before implementing SSCM, a company must first understand the critical aspects that can lead to the successful implementation of sustainable practices. This research work, which employs the Grey Decision-Making Trail and Evaluation Laboratory (DEMATEL) technique, intends to identify and examine the critical components of SSCM adoption in the context of a developing economy. By incorporating unpredictability and ambiguity into the estimating process, Grey DEMATEL has the greatest potential for increasing the effectiveness and success of the process. The electronics industry in Bangladesh is the subject of this research. SSCM is critical for the development of Bangladesh's electronics industry. Moktadir et al. (2018), textile industry (Ahmed et al., 2018), and chemical industry (Shohan et al., 2020) in Bangladesh are examples of previous work by the authors on SSCM approaches in the context of the leather industry. As a result of lack of manufacturing capacity and technological competency, Bangladesh's electronics sector is still in its early stages. Bangladesh's electronic goods manufacturing capacity is insufficient to meet the country's growing demand for electronic goods. As a result, it is critical that the present efforts paid on this issue. Building, maintaining and growing a long-term nexus between environmental and economic performance is more crucial in the electronics business than any other industry. When it comes to identifying success elements and ensuring, it performs successfully in the implementation of SSCM, is a vital decision. Without sustainable supply chain management, a company cannot grow successfully, and this is where they face a huge difficulty. And the Bangladeshi electronics industry is no exception. Consequently, in order to develop a long-term supply chain management strategy for determining the root cause of the problem. And the sole objective of this study is to determine the problem. This research focuses onto determine the critical success factors (CSFs) for the deployment of SSCM in the electronics industry and to investigate the links between the CSFs that have been found using the Grey DEMATEL approach. According to the objectives of this study, CSFs for implementing SSCM in Bangladesh's electronics industry have been investigated in this paper.

2. MATERIALS AND METHODS

2.1. Framework for Research

The Grey DEMATEL technique is used to evaluate the main CSFs. The steps in the suggested research are as follows.

Table 1 Possible CSFs for implementing sustainable supply chain in Z industries Ltd.

Factor codes	Factor names
F1	Hazardous material
F2	Environmental disaster
F3	Energy consumption
F4	Reverse logistics
F5	Green design
F6	Cost reduction
F7	Reduction of fines for environmental disaster
F8	Organizational capabilities & efforts
F9	Corporate Social Responsibilities (CSR)
F10	Regulations and standards (e.g. ISO 14000)
F11	Environmental friendly products
F12	Environmental collaboration with customers
F13	Training and Education
F14	Availability of information
F15	Global marketing
F16	Competitive advantage
F17	Competitive pressures towards greening
F18	Supplier pressure and willingness
F19	Environmental collaboration with suppliers
F20	Health and safety

Step 1 Critical aspects for an electronics company to consider.

A company's performance can be assessed based on a variety of variables. These criteria are dependent on the type of product or service it offers. The list of factors is derived from the each company's statistics data. The criteria are listed in Table 2.

Table 2 Selected CSFs for Z Industries Ltd.

Factor codes	Factor Names
F1	Hazardous Material
F2	Energy Consumption
F3	Regulations and standards (e.g. ISO 14000)
F4	Cost Reduction
F5	Reduction of fines for environmental disasters
F6	Corporate social responsibilities (CSR)
F7	Training & education
F8	Competitors pressure towards greening
F9	Organizational capabilities & efforts
F10	Health & safety

Table 3 Linguistic variables for the importance weight of each factor with grey numbers

Linguistic Variables	Numbers	Grey Number
No influence	0	[0,0]
Low influence	1	[0,0.25]
Medium Influence	2	[0.25,0.5]
High Influence	3	[0.5,0.75]
Extreme Influence	4	[0.75,1]

Step 2 Determination of the factors required for effective SSCM implementation using Grey DEMATEL. The Grey DEMATEL technique was used to study many such components and their interrelationships.

Step 3 Implementation of the factors that have been acquired. The Grey DEMATEL approach is used to assist in the determination of a trustworthy correlation between several parameters that would otherwise be difficult to determine. The stages required in determining important success criteria using Grey DEMATEL are as follows:

Stage 1: Creating the matrix with direct influence: The value of the association between the components is calculated using a scale of 0-4 and the expert's judgment. Each scale value shows the degree to which each component has an impact on one another.

Stage 2: Calculating direct-influenced normalized matrix: To avoid using different units and reduce variability, the data must first be standardized and because the variation of one data differs from that of other data, it is essentially required. To construct the array between 0 and 1, an appropriate value is obtained from the original value. It is a way of converting original data to equivalent data in general. If the answer is to be maximized, the following formula is used to normalize it into an appropriate range using larger-is-better characteristics.

$$x_i^*(k) = \frac{x_i^0(k) - \min \quad x_i^0(\mathrm{k})}{max x_i^0(\mathrm{k}) - \min x_i^0(\mathrm{k})}$$

Here, i = 1,...., m; k = 1,…,n., mis the number of experimental data and n is the number of responses. xi(k) denotes the original sequence, *xi*(k)* denotes the sequence after the data preprocessing, max xi (k) denotes the largest value of xi (k), min xi (k) denotes the smallest value of xi(k), and x is the desired value.

Stage 3: The following formula is used to compute the Grey Relational Coefficient, ξi(k), from the normalized data.

$$\xi_i(k) = \frac{\Delta \min + \xi \Delta \max}{\Delta oi \ + \ \xi \Delta \max}$$

Here, Δoi is the reference sequence's and comparability sequence's deviation sequences

$$\Delta oi = ||x_0(k) - x_i(\mathrm{k})||$$

The reference sequence is denoted by x0 (k) and the comparability sequence is denoted by xi (k). The absolute differences (Δoi) of all comparing sequences' minimum and maximum values are Δmin and Δmax. The range of ζ 0 to 1 is the distinguishing or identifying coefficient. Typically, the value of ζ is set to 0.5.

Table 4 Average Direct Relation Matrix

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	0	4	3	2	3	1	2	2	2	3
F2	3	0	2	1	1	1	2	1	1	3
F3	2	2	0	3	2	3	1	2	1	2
F4	1	1	3	0	2	1	2	3	2	2
F5	2	1	3	1	0	1	1	2	1	2
F6	1	3	3	3	1	0	2	2	3	2
F7	1	3	2	4	1	2	0	1	2	4
F8	3	2	1	2	1	2	1	0	2	2
F9	2	3	1	2	2	3	1	2	0	1
F10	4	4	3	2	2	2	3	1	2	0

Stage 4: Grey Relation Diagram: The values in the Grey Relation Co-efficient matrix is used to calculate Di+Ri and Di-Ri. If we specify the Grey Relation Co-efficient Matrix as "GRC" matrix, then-

Di = Row values in GRC matrix
Ri = Column values in GRC matrix

Di+Ri is known as "Prominence", while Di-Ri is known as "Relation". Di+Ri emphasizes the significance of the criterion and it generates an index that depicts the complete influence of criteria i both provided and received. The "relation" depicts the net influence that criteria i has on the system. It's the "cause factor" if Di-Ri is positive, and it is the "effect factor" if Di-Ri is negative.

Stage 5: For Grey Relational Grade (GRG)-

$$\gamma_i = \frac{1}{n}\sum_{k-1}^{n} \quad \omega_k(k)\xi_i(k)$$

Where, $\omega_k(k) = 1$ and n = number of response attributes, where γ_i is the requisite grey relational grade.

Table 5 Normalized matrix

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	0.00	1.00	1.00	0.50	1.00	0.33	0.67	0.67	0.67	0.75
F2	0.75	0.00	0.67	0.25	0.33	0.33	0.67	0.33	0.33	0.75
F3	0.50	0.50	0.00	0.75	0.67	1.00	0.33	0.67	0.33	0.50
F4	0.25	0.25	1.00	0.00	0.67	0.33	0.67	1.00	0.67	0.50
F5	0.50	0.25	1.00	0.25	0.00	0.33	0.33	0.67	0.33	0.50
F6	0.25	0.75	1.00	0.75	0.33	0.00	0.67	0.67	1.00	0.50
F7	0.25	0.75	0.67	1.00	0.33	0.67	0.00	0.33	0.67	1.00
F8	0.75	0.50	0.33	0.50	0.33	0.67	0.33	0.00	0.67	0.50
F9	0.50	0.75	0.33	0.50	0.67	1.00	0.33	0.67	0.00	0.25
F10	1.00	1.00	1.00	0.50	0.67	0.67	1.00	0.33	0.67	0.00

Table 6 Deviation sequences

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	1.000	0.000	0.000	0.500	0.000	0.667	0.333	0.333	0.333	0.250
F2	0.250	1.000	0.333	0.750	0.667	0.667	0.333	0.667	0.667	0.250
F3	0.500	0.500	1.000	0.250	0.333	0.000	0.667	0.333	0.667	0.500
F4	0.750	0.750	0.000	1.000	0.333	0.667	0.333	0.000	0.333	0.500
F5	0.500	0.750	0.000	0.750	1.000	0.667	0.667	0.333	0.667	0.500
F6	0.750	0.250	0.000	0.250	0.667	1.000	0.333	0.333	0.000	0.500
F7	0.750	0.250	0.333	0.000	0.667	0.333	1.000	0.667	0.333	0.000
F8	0.250	0.500	0.667	0.500	0.667	0.333	0.667	1.000	0.333	0.500
F9	0.500	0.250	0.667	0.500	0.333	0.000	0.667	0.333	1.000	0.750
F10	0.000	0.000	0.000	0.500	0.333	0.333	0.000	0.667	0.333	1.000

Table 7 Grey Relation co-efficient

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	0.333	1.000	1.000	0.500	1.000	0.429	0.600	0.600	0.600	0.667
F2	0.667	0.333	0.600	0.400	0.429	0.429	0.600	0.429	0.429	0.667
F3	0.500	0.500	0.333	0.667	0.600	1.000	0.429	0.600	0.429	0.500
F4	0.400	0.400	1.000	0.333	0.600	0.429	0.600	1.000	0.600	0.500
F5	0.500	0.400	1.000	0.400	0.333	0.429	0.429	0.600	0.429	0.500
F6	0.400	0.667	1.000	0.667	0.429	0.333	0.600	0.600	1.000	0.500
F7	0.400	0.667	0.600	1.000	0.429	0.600	0.333	0.429	0.600	1.000
F8	0.667	0.500	0.429	0.500	0.429	0.600	0.429	0.333	0.600	0.500
F9	0.500	0.667	0.429	0.500	0.600	1.000	0.429	0.600	0.333	0.400
F10	1.000	1.000	1.000	0.500	0.600	0.600	1.000	0.429	0.600	0.333

2.3. Data Collection and Analysis

2.3.1 Data Collection

The developed methodology has been tested by obtaining relevant data from an electronics manufacturing company of Bangladesh. The data were collected from Z Industries Ltd. Initially, 20 Possible CSF's (Table 1) for implementing green supply chain were identified from the relevant literature, company's experienced person and managers from two companies including Y and Z Industries Ltd. (Table 11). The questionnaire data are taken from the experts. The feedback provided by the experts was summarized in Table 12. After taking expert opinions, 10 factors from the initial 20 were selected following Pareto analysis. The corresponding data are given in Table 13. The lists of the selected CSFs are given in Table 2.Data are collected in two steps:

Step 1: Success factors relevant to the implementation of SSCM were acquired with the help of previous literature review and from company data.

Step 2: To useGrey DEMATEL model, expert's opinion on the influence of each factor was obtained. The average direct relation matrix is given in Table 4. This was obtained based on the ranking of each factor on a scale of 0-4 by various experts given in Table 3. The data obtained from each expert was averaged giving the average direct relationship matrix. This data was normalized to obtain the normalized matrix given in Table 5. Using the normalized matrix and inverse of the identity matrix of the normalized matrix the total relation matrix was obtained and is given in Table 6**.**

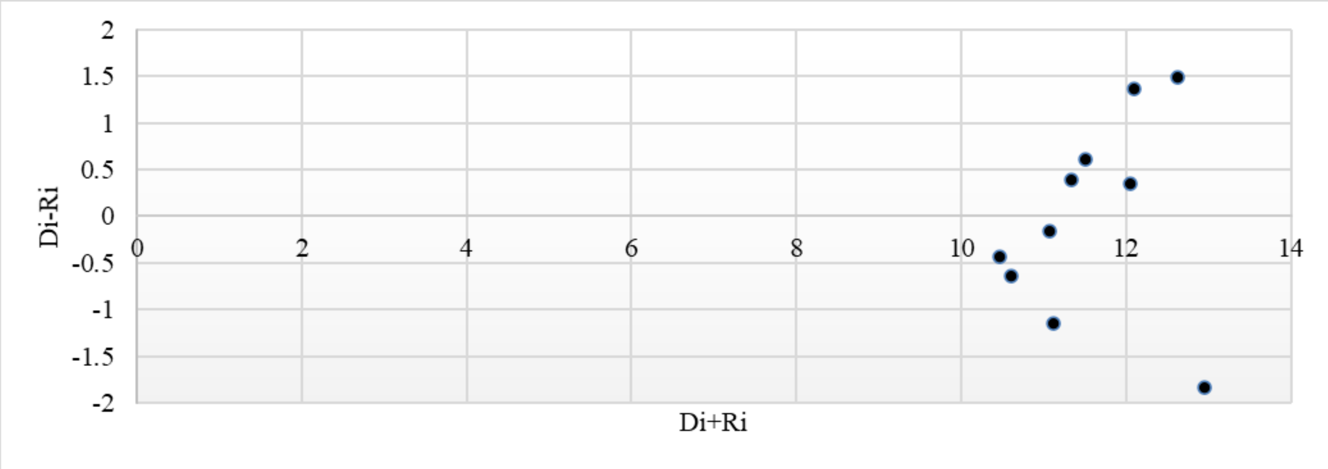

Fig. 1 Grey relations diagram (● CELLRANGE)

3. RESULTS AND DISCUSSION

The DEMATEL method is applied based on the expert opinion found as shown in Table 4. The total relation matrix is obtained and based on this matrix; the effects that success factors exert (Di) and receive (Ri) are calculated. The value of ($Di + Ri$) gives the degree of importance of that success factors while subtracting them ($Di - Ri$) gives the net effect. Table 8 represents the values of Di,, ($Di - Ri$) and ($Di + Ri$) for all success factors. The rows and columns of total relation matrix were tabulated to obtain the degree of importance and net effect. Fig. 1 presents the Grey Relations diagram of the success factors: it represents ($Di - Ri$) with respect to ($Di + Ri$).The factors having a positive net effect are categorized as cause factor and factors having a negative net effect are categorized as effect factor as shown in Table 8. In the cause and effect diagram shown in Fig. 1, factors at the top are cause factors and factors at the bottom are effect factors. Fig. 1 illustrates the success factors in descending order, it is observed that F10: "Health & safety" has the highest given value, while F2: "Energy Consumption" has the lowest given value.

Table 8 Grey relation

	Di	Ri	Di+Ri	Di-Ri
F1	6.729	5.367	12.096	1.362
F2	4.983	6.134	11.117	-1.151
F3	5.558	7.391	12.949	-1.833
F4	5.862	5.467	11.329	0.395
F5	5.02	5.449	10.469	-0.429
F6	6.196	5.849	12.045	0.347
F7	6.058	5.449	11.507	0.609
F8	4.987	5.62	10.607	-0.633
F9	5.458	5.62	11.078	-0.162
F10	7.062	5.567	12.629	1.495

The critical success factors of Z Industries Ltd. could be identified and prioritized by observing both Fig. 1 and Fig. 2. Among all the factors in the cause group, the following have the highest given impact: Health and safety (F10),

Table 9 Cause and effect factors

Cause	Effects
1. Hazardous Material 2. Cost Reduction 3. Corporate social responsibilities 4. Training & education 5. Health & safety	1. Environment management certification (ISO14000) 2. Energy Consumption 3. Reduction of fines for environmental disasters 4. Competitors pressure towards greening 5. Organizational capabilities & efforts

Hazardous Material (F1), Corporate Social Responsibilities (F6), Training and education (F7). Therefore, these four factors can be considered as the most critical success factors. As shown in Fig. 1, these factors form a cluster of great net-effect and degree of importance. These cause factors have higher given impact, so more attention should be exerted to strengthen them in order to enhance the effect factors, as a result, i.e., improving these four factors can easily enhance others.

3.1. Analysis of Critical Success Factors

The critical success factors of Z Industries Ltd. could be identified by calculating Grey Relation Co-efficient (Table 7) and then prioritized by Grey Relation Grade (GRG) shown in Table 10. Among all the factors in the cause group, the following have the highest impact: Health & Safety (F10), Hazardous Material (F1), corporate social responsibilities (CSR) (F6), Training & education (F7). Therefore, these four factors can be considered as the most critical success factors. As shown in Fig. 1, these factors form a cluster of great net-effect and degree of importance. These cause factors (Table 9) have higher given impact, so more attention should be exerted to strengthen them in order to enhance the effect factors, as a result, i.e., improving these four factors can easily enhance others. Factors namely Energy Consumption (F2), Competitors pressure towards greening (F8), Reduction of fines for environmental disasters(F5), Organizational capabilities & efforts (F9), Regulations and standards (e.g. ISO 14000) (F3),Cost Reduction(F4) are subsequent important factors.

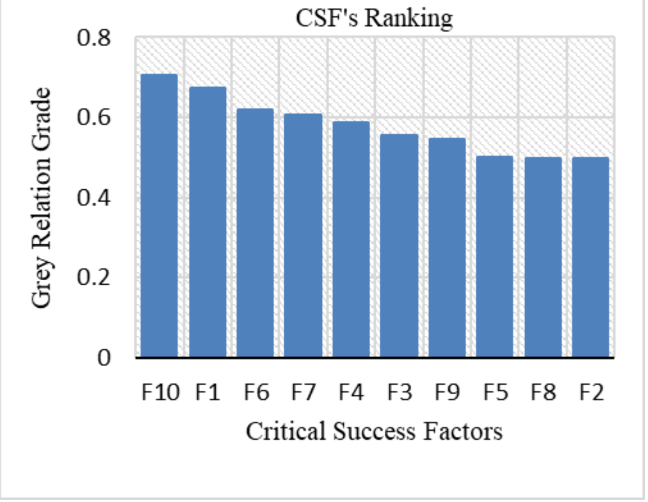

Fig. 2 Ranking of Success Factors Based on Grey Relation Grade.

Table 10 Grey relation grade

Factor code	GRG	Priority
F10	0.70619	1st
F1	0.672857	2nd
F6	0.619524	3rd
F7	0.605714	4th
F4	0.58619	5th
F3	0.555714	6th
F9	0.545714	7th
F5	0.501905	8th
F8	0.498571	9th
F2	0.498095	10th

Menon & Ravi (2021) designated sustainable supply chain management strategies to effectively direct business functions and activities in the electronics industry. Their study mainly focused on sustainable product and processes. Factors having high degree of importance and high net effect are considered as critical success factors. Thus, Health& Safety (F10), Hazardous Material (F1), corporate social responsibilities (CSR) (F6) and Training & education (F7) are the critical factors for successful implementation of sustainable supply chain management in the Z Industries Ltd (Fig. 3). The type of technology used for the manufacturing process determines if it will affect the health and safety of the workers. There should not be use of hazardous materials of any kind. The raw materials and parts for the electronic products are bought from suppliers. Therefore, it is important that the supplier to the company have the green factor in their products. To implement SSCM in the company, it is of vital importance to make sure that the company is able to make a profit using SSCM initiative. Competitiveness among companies is a common scenario that helps a company in building SSCM and tries to better itself from its competitor. Once a company starts to establish SSCM into its supply chain system, other companies will be motivated to follow SSCM practices to make sure they are in level with them.

Table 11 Industry experts

Companies	Affiliation	Expert's Years of Experience
Y Industries Ltd.	Executive	5
	In-charge, Corporate Marketing	7
	Assistant Manager	5
	Network Admin	4
	Manager, HR & Compliance	8
	Assistant Manager	7
Z Industries Ltd.	Deputy Manager, Legal & Logistics	6
	Executive Officer	7
	Inventory Officer	8
	Production Executive	9
	Assistant Manager, Supply Chain & Safety Management System	6
	Operating Manager, Factory	10

4. CONCLUSION

There are several key elements that are connected to an organization's supply chain, and these characteristics make the idea of SSCM challenging to execute in developing Bangladesh. However, Bangladesh can use SSCM practices in order to reduce environmental collisions and boost financial growth, and by estimating CSFs during the implementation of SSCM, better solutions to these problems can be discovered in the case of company performance. In the present study, 10 CSFs were selected by the consultation and approval of the industrial experts for the implementation of SSCM. From results and findings, the factors with the highest impacts are disclosed and they are Health & Safety, Hazardous Material, Corporate Social Responsibilities (CSR), Training & Education. These are the most critical success factors to keep in mind while implementing SSCM. Because these factors have the most impact, more effort may be invested into improving them in order to improve overall supply chain management sustainability. Though there are many approaches to increase sustainability, the advantage of employing the Grey DEMATEL technique to locate CSFs is that it may incorporate unpredictability and ambiguity into the estimation process, making it a fruitful and triumphant outlook. The traditional DEMATEL technique may be unable to cope with such unpredictability and uncertainty.

Table 12 Experts’ feedback on critical success factors for implementing Green Supply Chain Management (GSCM)

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20
E1	•		•			•		•	•	•			•			•				•
E2		•					•		•	•			•		•		•			•
E3	•		•			•	•		•			•							•	•
E4						•		•	•	•			•		•			•		•
E5	•		•	•		•	•		•		•						•			•
E6	•		•			•		•	•	•			•			•				•
E7	•		•		•		•			•			•				•			
E8	•	•		•			•		•	•				•	•		•			•
E9	•				•	•	•		•	•			•				•			•
E10	•		•			•		•	•			•	•							•
E11	•					•	•		•		•			•			•			•
E12				•		•	•	•		•			•			•	•			•

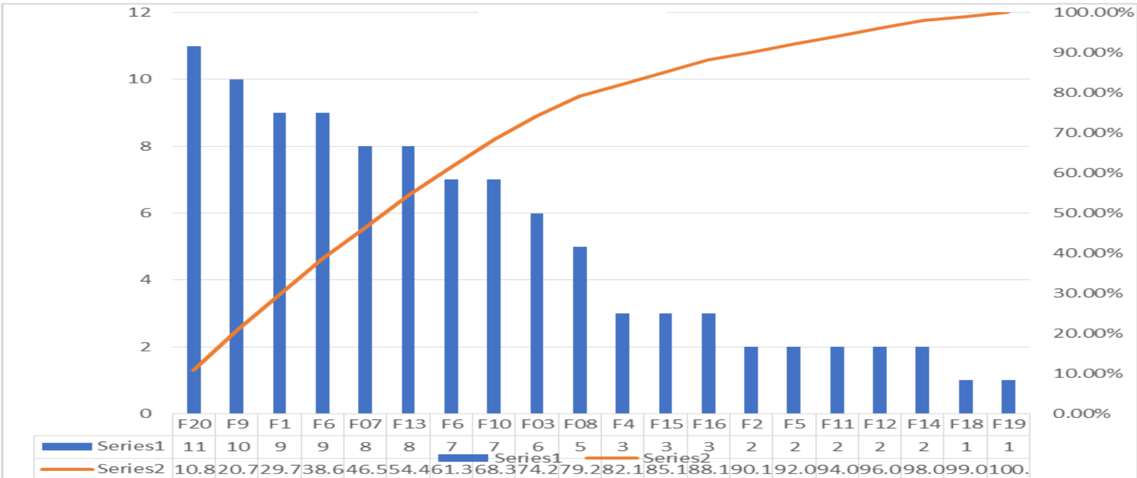

Fig. 3 Experts’ feedback on critical success factors for implementing Sustainable Supply Chain Management (SSCM).

As a result of this strategy, industrial and corporate organizations can identify informal links among CSFs, allowing them to use SSCM to construct plans and sustain improvements while meeting environmental, economic, and social needs. Meanwhile, this result is only applicable to the particular type company. The most recent procedures can improve the outcome in business or Supply chain management and different methods can be used for different businesses for obtaining better competitive advantage in Supply Chain Management, i.e. Business.

This study focuses on the electronics company industries only in Bangladesh. This study has been observed at the key success factors (CSFs) for Bangladeshi electronics manufacturing company using the Grey-DEMATEL technique. Other methodologies for analyzing critical success factors (CSFs), such as DEMATEL, Fuzzy

DEMATEL-ANP, ISM, and others, can be used for sustainability implementation in addition to Grey-DEMATEL. This paper has been considered 20 CSFs, of which 10 are selected with the support of specialists, however there are many more CSFs that can be utilized to execute SSCM using various ways. The key success factors (CSFs) can vary depending on the firm and sector categories. As a result, more research and studies are needed

Table 13 Experts’ feedback on critical success factors for implementing Sustainable Supply Chain Management (SSCM)

Factor Codes	Number of Respondent	Cumulative	Cumulative %
F20	11	11	10.89%
F9	10	21	20.79%
F1	9	30	29.70%
F6	9	39	38.61%
F07	8	47	46.53%
F13	8	55	54.46%
F6	7	62	61.39%
F10	7	69	68.32%
F03	6	75	74.26%
F08	5	80	79.21%
F4	3	83	82.18%
F15	3	86	85.15%
F16	3	89	88.12%
F2	2	91	90.10%
F5	2	93	92.08%
F11	2	95	94.06%
F12	2	97	96.04%
F14	2	99	98.02%
F18	1	100	99.01%
F19	1	101	100.00%

to investigate key success factors (CSFs) in the context of a developing economy like Bangladesh, as it remains a difficult issue.

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