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Abstract: Recent Supply Chain Management Systems (SCMS) that is based on newer technologies are intelligent enough to lower costs, improve product quality, and speed up the decision-making process in the manufacturing operation. The reduction of overall environmental impact, is a goal of the Green Supply Chain Management (GSCM) systems. It is achieved by integrating environmentally friendly processes into SCMS. The main and most crucial role in achieving the goal of sustainable development is played by the GSCM practices. It is proved that, the adoption of IoT technology into the GSCM systems can increase its performance and productivity. The goal of this paper is to examine the Critical Success Factors (CSFs) for the efficient adoption of IoT and green solutions throughout the supply chain for the manufacturing sector. As a result of pressure from the government and increased customer awareness of environmental issues, manufacturers are currently focusing on GSCM that is enabled by IoT gadgets. The selection and prioritization of IoT-enabled GSCM success variables is performed, in this paper, using bipolar neutrosophic-DEMATEL approach.

Keywords: Green Supply Chains, IoT, Critical Success Factors, DEMATEL Bipolar-Neutrosophic.

1. Introduction

Currently, because of the increased awareness of sustainability and environmental protection, Green Supply Chain Management (GSCM) has gained a lot of popularity [1]. Industries are required to consider eco-friendly strategies to improve the environment and their green reputation [2]. In this context, organizations around the world have implemented more dependable techniques to encourage sustainable and green management at all levels of their supply chain as a result of changes in rules, legislation, lifestyle, and notably customer tastes in society [3]. The major goals of GSCM are to minimize or eliminate the environmental harms caused by supply chain operations in order to accomplish sustainable development goals [4]. Design, buying, production, storage, and logistics processes should thus be restructured by businesses as a result of GSCM efforts [5]. Reverse logistics is also a crucial component of GSCM for recovering value from discarded goods and materials or properly recycling them [6]. The use of GSCM has several advantages for businesses and communities. The environmental performance of GSCM is increased while waste production is minimized. Companies will be guided by GSCM to increase their eco-proficiency. Companies can stay up and increase their level of commercial performance since GCSM leads to the enhancement of activities in the economic and environmental fields [4]. The implementation of Internet of Things (IoT) technology in the GSCM parts can be viewed to add an intelligence and sustainability assets to GSCM systems [7]. In this context, researchers and students have offered numerous definitions for GSCM. For instance, Hervani et al [8], explicitly used GSCM to integrate sustainable design, efficient material handling, green product procurement, environmentally conscious supplier cooperation, and waste management. However, according to Jayant and Tiwari [9], GCSM is a novel idea for determining the right course for developing products that are compliant with environmental laws and pre-established standards, and businesses require it as a tactic to collaborate on environmental challenges.

According to statistical data, GSCM can control 80% of environmental consequences by using ecologically friendly approaches [10]. Therefore, it is an important issue to identify and analyze the Critical Success Factors (CSFs) for the good implementation of the IoT-Enabled GSCM. It is the primary objective of this investigation to analyze the CSFs of GSCM. As a result, the organizations focus only on these critical factors not all the factors included in the implementation process. As the more you focus on smaller number of factors the more you can give your best in all of them. We will help this organizations by using the opinions of three experienced experts to build an integrated strategy of the decision-making trial and evaluation laboratory (DEMATEL) and Bipolar-Neutrosophic sets (BNSs) to remove the vagueness of those opinions by using a wider scale to identify critical success factors by grouping them into cause and effect groups [11], [12]. DEMATEL is a method used to develop and analyze a structural model of relationships and interdependences between success factors into a matrices or digraphs [13]–[16]. It will assist the decision-makers in determining the success factors of greater influence, which will be the critical success factors, by dividing these factor to cause and effect based on their values and their importance.

The following goals are the main emphasis of the research paper:

1. Identifying the critical success factors (CSFs) for modern GSCM systems to provide competitive advantages to organizations.
2. This work also aims at clarifying contextual relationships between the CSFs and prioritizing these CSFs using an integration of DAMTEL and the BNS methods according the opinions of three experts.
3. Considering the modern information technological (IT) paradigms such as IoT [17], [18], Big Data [19], [20], and Big Data Analytics (BDA) [21]–[23] that are now becoming a critical parts for implementing an intelligent and more productive GSCM systems.

The majority of publications in the literature used the fuzzy set, which has limitations because it only considers the membership function and ignores the non-membership function and indeterminacy function [24], [25].Utilizing Smarandache's Neutrosophic sets (NSs), a generalization of intuitionistic fuzzy sets, we were able to overcome this flaw. The focus of NS is on the membership and non-membership functions, and it does take the indeterminacy function into account. This strategy can deal with incomplete knowledge in the actual world because it is a generalization [26].

The following sections are organized as follows: Section 2 discusses the literature review of IoT-enabled GSCM supply chain and its CSFs .Section 3 introduces the basic concepts for the research. Section 4 presents the research methodology which is the integration of bipolar neutrosophic sets and the DEMATEL method. We also introduce Application of BNS-DEMATEL approach for analyzing the CSFs of the IoT-enabled GSCM in section 4. Section 5 discusses the outcomes of the research. In section 6 we conclude the research.

2. Literature review

In academic and professional communities, GSCM is gaining popularity. It is a relatively new idea that's gaining popularity with suppliers and producers centered on improving green processes, reducing waste through reverse logistics, raising the caliber of products across their entire life cycles, and reducing harmful environmental activities [27]. In this section we will focus on the key aspects examined in the related works of experimental GSCM implementation, one of the sustainability's branches [28], to determine the most important elements for its successful implementation. Traditional SCM methods, on the other hand, can have a negative influence on the environment and act as a source of pollution [29]. Examples include the production, distribution, and waste of raw materials. Therefore, it is crucial to incorporate green practices like green manufacturing, green packaging, and reverse logistics into overall SCM activities in order to safeguard the environment [30]. To preserve the environment against unwelcome activities, many nations seek to set environmental standards and regulations for the industry. In order to achieve sustainable environmental, economic, and social development, these standards mandate that enterprises use green and environmentally friendly practices throughout all SCM activities [31]. As a result, numerous researchers have demonstrated in their work how important it is to adopt GSCM in a way that also considers the organization's environment.

2.1 Utilization of MCDM tools in the GSCM implementation

Researchers' interest in employing causal analysis in their studies has grown over the past few years. The primary explanation is that problems arise for a variety of reasons. In order to identify the relative relevance of the components, decision-makers must adopt a technique known as the Multi-Criteria Decision Making (MCDM) approach when evaluating such an issue [10]. MCDM is subfield of operations research methodologies where the multifaceted decision-making problem can be reduced to a smaller problem [32]. The MCDM considerably helps to organise and prioritise the decision-making challenges. It also supports decision-makers in analyzing, choosing, and ranking options based on the assessment of numerous decision problem criteria [33]. There is a need for an efficient technique to assess the various aspects that function as GSCM components. Consequently, the MCDM approaches remain the best choice. The evaluation of green SCM decision problems makes extensive use of the MCDM approaches, including the DEMATEL method, Analytical Hierarchy Process (AHP) , Analytic Hierarchy Process (ANP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Linear Programming, and Fuzzy Programming [1]. This study use an integrated approach of the DEMATEL method and BNSs to identify the CSFs for the near optimal implementation of the GSCM systems.

2.2 Proposed CSFs for the successful GSCM implementation

For the purpose of implementing IoT-Enabled GSCM practices, this study identifies numerous significant key factors. These green indications are thought of as a supplementary tools for SCM operations. The purpose of this study was to determine the key CSFS from the standpoint of the practices applied by green supply chain enabled by IoT technology using a thorough set of literature reviews. A thorough assessment of the literature led to the identification of the twenty CSFs under two key dimensions. The two main dimensions are: green enablers which include the green drivers for implementing the GSCM. The second dimension is the IoT enablers which include the main drivers for enabling the implantation of IoT in the GSCM system. The full description of the CSFs is presented in table 1. It has been determined that the adoption of green SCM methods frequently uses MCDM approaches. These strategies are thought to be crucial for resolving difficult decision-making issues. This study focus on prioritizing the CSFs for implementing the IoT-enabled GSCM successfully using an integrated approach of the DEMATEL method and BNSs to remove the vagueness of those opinions by using a wider scale to identify critical success factors by grouping them into cause and effect groups.

Table 1: Proposed CSFs for the Successful implementation of IoT-Enabled GSCM

Code	CSF	DESCRIPTION	Source
A	**Green enablers**		
F1	Influence from investors and stakeholders	Investors or stakeholders have an interest in the company. Additionally, they are entitled to collect profits that the business publishes.	[34], [35]
F2	Waste management	Wastes are substances that are not primary products and that the producer wants to dispose of because they are no longer needed for the producer's own purposes of production, transformation, or consumption.	[25], [36]
F3	Environmental regulations	Organizations are required to abide by environmental regulations set forth by the government (such as hazardous and poisonous regulations), and penalties are always a possibility if they do not.	[37]–[40]
F4	Global competitive advantage	Sustainable business practises give organisations a considerable competitive advantage over those that don't, which ultimately helps the organization's bottom line. Global competitiveness is a major force behind an organization's adoption of sustainable practices.	[41], [42]
F5	Management of toxic/ harmful/ hazardous materials and waste and pollution preventative measures	Sustainable business practices help organizations control their toxic waste production, which has a negative impact on both the environment and people, as well as their consumption of hazardous materials.	[43]–[45]
F6	Green packaging and transportation	The rising CO2 gas emissions during the 1990s have put the environment at risk due to freight transportation, which is why green transportation was started. Green packaging is characterized as being constructed entirely of natural plants and being environmentally friendly. It is safe for the environment, human health, and the welfare of cattle.	[46]–[48]
F7	Top management commitment	It occurs when individuals holding top rank positions directly contribute to a specific and critically important area of a business.	[49]–[51]
F8	Greening competition pressures	Competitive advantages associated with going green, better brand perception, and financial gains will all benefit competitors who have environmental management systems.	[52]
F9	power negotiations along the supply chain	Requirements, advantages, and restrictions that the market imposes on the participants of a negotiation.	[53], [54]
F10	Green marketing	Companies can promote their goods based on their "green" reputation, giving them a competitive edge in the global marketing arena. Additionally, because these businesses are	[55]

		adhering to environmental regulations, new markets are now available to them.	
F11	Standards and regulations (ISO 14000)	Certifications encourage businesses to improve their quality while using a green strategy. Environmentally friendly operations between suppliers and customers need the use of ISO 14000.	[56], [57]
F12	Reverse logistics	It addresses the activities involved in product reuse. The reverse logistics also includes actions for refurbishing and remanufacturing.	[58]
F13	creation of highly qualified and competent human labor	SCM thought leaders advise businesses to take a more proactive approach to developing SCM people with the skills and industry-specific competences required to manage supply chain processes that are becoming more complicated and strategically significant. This will help in the management of the green processes.	[59]
F14	green practices, policies, and infrastructure	Companies must make considerable changes to their management policies, operations, infrastructure, and products to successfully implement supply chain greening, frequently by adopting new business models.	[60], [61]
F15	Collaboration with suppliers	Although this CSF doesn't act as a direct main driver, it should be underlined that supply chain collaboration and integration can more effectively advance sustainability. Incorporating the thoughts and suggestions provided by suppliers can be quite beneficial.	[62], [63]
F16	Recycling and lifecycle management	Establish a set of standards for the collection, handling, and recovery of used electronics and electrical equipment, and hold producers financially accountable for these actions.	[64]
B	**IoT enablers**		
F17	Radio Frequency Identification (RFID) and Global positioning system (GPS)	The smart GSCM systems enabled the real-time location of people and resources both indoors and outside thanks to RFID and GPS technologies. They made it possible to manage stock updates, transportation, and item tracking.	[7], [65]
F18	Cloud computing and IoT applications	Through the use of the Internet, cloud computing reduces uncertainty for decision-makers by offering services like infrastructure, platform, and software. It enables decision-makers in GSCM systems of any business to make decisions at the appropriate time, location, product, and quantity. It host the IoT applications the enable the management and tracking of the GSCM entities.	[18], [66]–[69]
F19	Sensor technologies and sensor network	Sensor and sensors network allow for the real-time data collection and transmission in the IoT-Enabled GSCM systems.	[70]–[72]
F20	Big Data and Big Data Analytics (BDA) tools	As a result of large amounts of data collected by the IoT sensors, Big data technologies must be adopted in the GSCM system for managing such volumes of data. BDA tools allow for the real-time analysis of the collected big data to provide GSCM decision makers with accurate and timely data.	[21], [23], [73]

3. Preliminaries

To fully describe our suggested strategy, this section is broken down into three subsections. We shall first give a brief overview of the neutrosophic sets. The DEMATEL approach will then be demonstrated. Finally, we will present the DEMATEL approach that we have proposed using BNS.

3.1 Neutrosophic Sets

In this part, the notion of a neutrosophic set is discussed, along with some of its operations, including the scoring, accuracy, and certainty functions that are used to compare BNSs. BNSs are successor to the neutrosophic sets, fuzzy sets, intuitionistic fuzzy sets, and bipolar fuzzy sets. The fuzzy set was utilised in a bulk of articles in the literature, but it has drawbacks because it only takes the membership function into account while ignoring the function of non-membership and the function of indeterminacy. We overcame this drawback by using the concept of Neutrosophic sets (NSs). The function of indeterminacy is considered, although the both of membership and non-membership methods are the main emphasis of NS [74], [75]. As a generalization, this method can deal with information gaps in the real world.

Definition 1. Let S be a points' space. And s∈S. A neutrosophic set N in S is described by the following three functions:

1. The indeterminacy-membership function $I^N(s)$.
2. The truth-membership function $T^N(s)$.
3. The falsity-membership function $F^N(s)$.

$T^N(s)$, $I^N(s)$, and $F^N(s)$ are actual nonstandard or standard subsets of $(s): S \to]-0,1+[$ and $F_N(s): S \to]-0,1+[$. Where the sum of T_N (s), I_N (s) and F_N(s), so 0− ≤ sup (s) + sup s + sup s ≤3+ is not limited.

Definition 2 [12]: A BNS N in ꜫ is characterised as an item with the form N={<s, $T^p(s)$, $I^p(s)$, $F^p(s)$, $T^n(s)$, $I^n(s)$, $F^n(s)$>: s ∈ ꜫ }, where T^p, I^p , F^p : ꜫ → [1, 0] and T^n , I^n , F^n : ꜫ → [-1, 0] . The positive membership degree $T^p(s)$, $I^p(s)$, $F^p(s)$ of an item ∈ ꜫ pointing to a BNS N and the negative membership degree $T^n(x)$, $I^n(x)$, $F^n(x)$ of an item ∈ ꜫ identifies a counter-property that is implicit and comparable to a BNS A , Assume that Ã=< T^p, I^p, F^p, T^n, I^n, F^n > be a Bipolar Neutrosophic Number (BNN).following that, the score function S (Ã), accuracy function a (Ã), and certainty function c (Ã) of a BNN are described as in the following relations:

$$S(\tilde{A}) = \frac{1}{6} * [T^p + 1 - I^p + 1 - F^p + 1 + T^n - I^n - F^n] \quad (1)$$

$$a(\tilde{A}) = T^p - F^p + T^n - F^n \quad (2)$$

$$c(\tilde{A}) = T^p - F^n \quad (3)$$

3.2 DEMATEL

The DEMATEL approach was developed to assess and depict the nature and intensity of the direct and indirect relationships between complex real-world aspects in a study system [76]. DEMATEL is a method for group decision-making that involves gathering ideas and determining the relationship between causes and effects in complex problems [77]. The DEMATEL method helps to uncover the optimal answer in solving problems involving complex systems by assessing the overall relationships between the structural parts of a study system and grouping elements into cause and effect groups [13], [78]. It is constructed upon the foundation of graph theory [2].

4. Proposed BNS-DEMATEL approach for analyzing the CSFs of the IoT-enabled GSCM

In this part we will integrate the DEMATEL method with BNS neutrosophic set to overcome the vagueness in the expert's opinions which will be used in DEMATEL matrices. The steps involved in the suggested approach are shown in Figure 1.

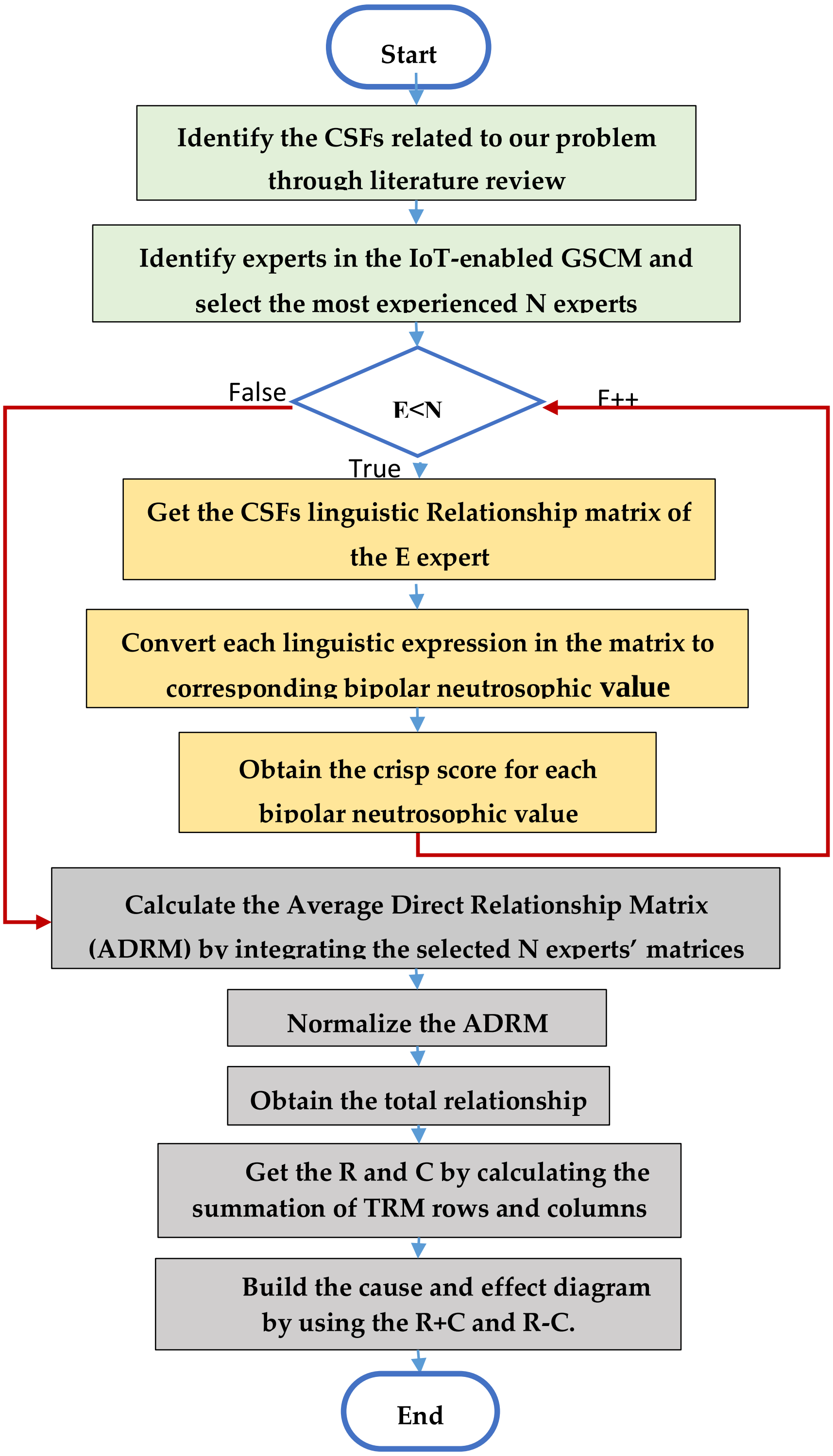

Figure 1: Steps of the Neutrosophic DEMATEL approach

Step 1: Identify the CSFs for the IoT-enabled GSCM

It is the first step in our model to discover the CSFs for implementing the green supply chain that is enabled by IoT gadgets. By surveying the literature, we have identified twenty CSFs for implementing the IoT-enabled GSCM. The identified factors are shown in table 1. We classified the identified CSFs into two groups. The first group is the critical factors for the green manufacturing. Where the second group include the factor required for enabling the GSCM by the IoT gadgets.

Step 2: Identify experts in the IoT-enabled GSCM and select the most experienced N experts:

We searched for experts having experience in Green supply chain management operations and IoT technology. After filtering the experts, we have selected the most experienced three experts in the fields of IoT and GSCM. The metadata about the selected experts is provided in table 2. We then provide our experts with a full description about the selected CSFs. Afterwards, we initiate our request of linguistic Relationship matrix from each expert.

Table 2: Experts' metadata

expert	Experience (years)	expertise	occupation	profession	Gender
E1	13	Very good	Industry	GSCM	Male
E2	10	Good	Industry	IOT-GSCM	Male
E3	9	Medium	Industry	IOT-GSCM	Male

Step 3: Get the CSFs linguistic Relationship matrix of each expert

Here, we make a pairwise comparison matrix between CSFs based on each expert's opinion using the linguistic expressions shown in figure 2. Table 3 show the linguistic relationship matrix for expert 1.

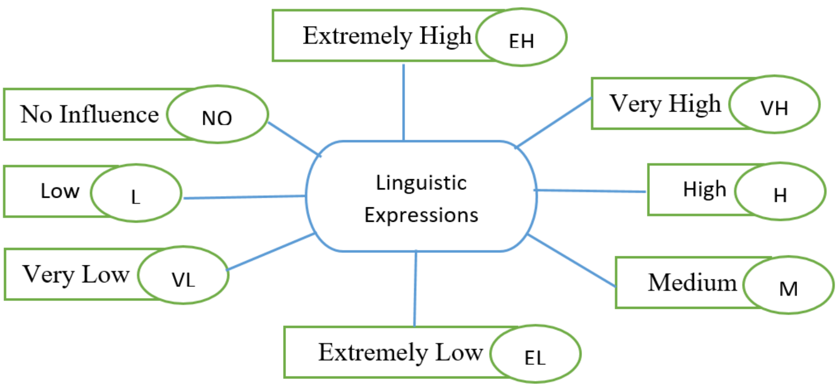

Figure 2: Linguistic expressions

Step4: Convert each linguistic expression in the linguistic Relationship matrix into corresponding bipolar neutrosophic value

Now, we will replace the linguistic expressions into its corresponding bipolar neutrosophic values according to table 4.

Step 5: Obtain the crisp score for each bipolar neutrosophic value

We firstly calculate the crisp score related to each bipolar neutrosophic value according to eq. (1). Table 5 show the calculated crisp scores for the linguistic expressions used in this study. In table 6 and table 7, we present crisp score matrix of expert 1.

Step 6: Calculate the Average Direct Relationship Matrix (ADRM) by integrating the selected N experts' matrices

In this step we will integrate the three collected matrices of the three experts into one matrix that is called average direct relationship matrix which represent an average of the observations collected from the chosen experts. Each value in the ADRM matrix is estimated according to the following equation:

$$ADRM_{i,j} = \frac{\sum_{E=1}^{N} V_{i,j}^{E}}{N} \quad (4)$$

Where $A_{i,j}$ is the ADRM value at row i and column j, it denote the degree to which the factor i affects the factor j, $V_{i,j}^{E}$ is the value of the crisp matrix at row i and column j for expert E, N is the number of experts. Table 8 and 9 show the ADRM of the three experts.

Step 7: Normalize the ADRM

In this step we will normalize the initial direct relationship matrix using the following equations.

$$S = Max\{\max_{1\le i\le N} \sum_{j=1}^{N} ADRM_{i,j}, \max_{1\le j\le N} \sum_{i=1}^{N} ADRM_{i,j}\}$$

(5)

$$NADRM = \frac{ADRM}{S} \quad (6)$$

Table 10 and 11 show the normalized ADRM.

Step 8: Obtain the total relationship matrix

Her, we obtain the total relationship Matrix using the following equation

$$TRM = NADRM * (I - NADRM)^{-1} \quad (7)$$

Where I is the identity matrix. Table 12 and 13 show the normalized ADRM.

Step 9: Get the Ri and Cj by calculating the summation of TRM rows and columns

we will calculate Calculate R+C (which indicates the degree of importance), R-C(which divide the CSFs into cause or effect groups, if the result is positive then it's in cause group (which has significant effect on the overall goal an need more attention) and if the result is negative then it's in effect group(which is affected by other factors easily but it's doesn't mean it is not important as every factor has his own influence on other factors as we if it has high important (high R+ C) and negative (R-C) such as F7 we can consider it as cause group) and by using the following equations

$$C = \sum_{j=1}^{N} TRM_{i,j}$$

(8)

$$R = \sum_{i=1}^{N} TRM_{i,j} \quad (9)$$

Table 14 show the summation of TRM rows and columns.

Step 10: Build the cause and effect diagram by using R+C and R-C

In this step we will build the diagram based on the result in the previous step we will use the values of $\mathrm{R}i+\mathrm{C}j$ as the horizontal axes and use the values of $\mathrm{R}i-\mathrm{C}j$ as the vertical axes and CSFs with positive values (above the x-axes) it's in cause group and CSFs with negative values (below the x-axes)) it's in effect group. Figure 2 show the casual diagram

Table 3: Linguistic relationship matrix for expert 1

Code	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20
F1	0	M	H	M	M	H	M	L	H	VH	H	VH	L	EL	H	EH	VH	VH	VH	VH
F2	H	0	EH	H	M	VH	H	M	VL	VL	M	EH	VH	H	M	L	VL	L	EL	L
F3	VH	VH	0	VH	H	EH	H	M	H	H	M	M	VL	H	VH	H	H	H	H	H
F4	M	EH	H	0	L	M	H	L	VL	H	VH	M	H	L	H	VH	H	H	H	H
F5	H	H	M	H	0	M	H	H	H	M	L	H	VH	M	EH	VH	H	VH	M	EH
F6	EH	M	VH	H	H	0	L	H	H	M	H	L	EH	H	H	H	EH	H	M	EH
F7	VH	H	M	M	M	H	0	VH	VH	VH	EH	VH	VH	VH	M	H	VH	VH	VH	EH
F8	L	M	M	M	H	M	H	0	M	EH	M	M	H	H	L	M	EH	EH	EH	EH
F9	M	VL	M	H	H	L	M	H	0	H	VH	H	M	M	H	VL	H	H	H	VH
F10	H	H	M	VH	M	VL	VH	L	H	0	M	M	H	H	M	L	EH	EH	EH	EH
F11	EH	H	VH	M	VH	EH	H	VH	VH	M	0	M	M	VL	EH	VH	VL	M	L	M
F12	H	VH	M	M	VL	VH	VH	VL	M	M	L	0	M	H	VL	H	EH	VH	EH	EH
F13	M	H	H	H	H	H	VH	M	VL	M	M	H	0	VH	L	EL	M	M	M	M
F14	M	M	H	EH	L	L	VL	EH	L	EH	M	VH	M	0	EH	M	VH	H	VH	VH
F15	H	L	M	L	H	M	EL	L	M	H	VH	H	M	L	0	VL	VM	H	H	VH
F16	M	M	VH	H	M	L	H	VL	VH	M	VL	VL	H	L	VH	0	VH	M	VH	H
F17	EH	H	M	VH	M	M	VH	VH	M	EH	M	EH	M	H	H	EH	0	EH	EH	VH
F18	VH	H	M	VH	H	H	H	VH	H	EH	M	VH	M	H	H	H	H	0	EH	EH
F19	H	H	M	VH	M	H	VH	VH	M	EH	M	EH	M	H	H	H	EH	EH	0	M
F20	VH	EH	H	VH	H	VH	EH	EH	VH	EH	H	EH	M	H	EH	H	H	EH	M	0

Table 4: Linguistic expressions with its corresponding bipolar neutrosophic value.

Linguistic Expression	Bipolar Neutrosophic value
EH	(1.00,0.00,0.10,-0.10,-0.90,-1.00)
VH	(0.85,0.15,0.20,-0.20,-0.70,-0.90)
H	(0.75,0.20,0.25,-0.25,-0.60,-0.50)
M	(0.50,0.50,0.50,-0.50,-0.50,-0.50)
L	(0.30,0.40,0.60,-0.30,-0.20,-0.10)
VL	(0.25,0.70,0.80,-0.55,-0.15,-0.30)
EL	(0.15,0.90,0.80,-0.65,-0.10,-0.10)
NO	(0.00,1.00,1.00,-1.00,0.00,0.00)

Table 5: Crisp scores for the Study linguistic expressions

Bipolar Neutrosophic Number Scale	Crisp score
(1.00,0.00,0.10,-0.10,-0.90,-1.00)	0.9500
(0.85,0.15,0.20,-0.20,-0.70,-0.90)	0.8167
(0.75,0.20,0.25,-0.25,-0.60,-0.50)	0.6917
(0.50,0.50,0.50,-0.50,-0.50,-0.50)	0.5000
(0.30,0.40,0.60,-0.30,-0.20,-0.10)	0.3833
(0.25,0.70,0.80,-0.55,-0.15,-0.30)	0.2750
(0.15,0.90,0.80,-0.65,-0.10,-0.10)	0.1667
(0.00,1.00,1.00,-1.00,0.00,0.00)	0.0000

Table 6: Part 1 of the crisp score matrix of expert 1

Code	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	0	0.5000	0.6917	0.5000	0.5000	0.6917	0.5000	0.3833	0.6917	0.8167
F2	0.6917	0	0.9500	0.6917	0.5000	0.8167	0.6917	0.5000	0.2750	0.2750
F3	0.8167	0.8167	0	0.8167	0.6917	0.9500	0.6917	0.5000	0.6917	0.6917
F4	0.5000	0.9500	0.6917	0	0.3833	0.5000	0.6917	0.3833	0.2750	0.6917
F5	0.6917	0.6917	0.5000	0.6917	0	0.5000	0.6917	0.6917	0.6917	0.5000
F6	0.9500	0.5000	0.8167	0.6917	0.6917	0	0.3833	0.6917	0.6917	0.5000
F7	0.8167	0.6917	0.5000	0.5000	0.5000	0.6917	0	0.8167	0.8167	0.8167
F8	0.3833	0.5000	0.5000	0.5000	0.6917	0.5000	0.6917	0	0.5000	0.9500
F9	0.5000	0.2750	0.5000	0.6917	0.6917	0.3833	0.5000	0.6917	0	0.6917
F10	0.6917	0.6917	0.5000	0.8167	0.5000	0.2750	0.8167	0.3833	0.6917	0
F11	0.9500	0.6917	0.8167	0.5000	0.8167	0.9500	0.6917	0.8167	0.8167	0.5000
F12	0.6917	0.8167	0.5000	0.5000	0.2750	0.8167	0.8167	0.2750	0.5000	0.5000
F13	0.5000	0.6917	0.6917	0.6917	0.6917	0.6917	0.8167	0.5000	0.2750	0.5000
F14	0.5000	0.5000	0.6917	0.9500	0.3833	0.3833	0.2750	0.9500	0.3833	0.9500
F15	0.6917	0.3833	0.5000	0.3833	0.6917	0.5000	0.1667	0.3833	0.5000	0.6917

F16	0.5000	0.5000	0.8167	0.6917	0.5000	0.3833	0.6917	0.2750	0.8167	0.5000
F17	0.9500	0.6917	0.5000	0.8167	0.5000	0.5000	0.8167	0.8167	0.5000	0.9500
F18	0.8167	0.6917	0.5000	0.8167	0.6917	0.6917	0.6917	0.8167	0.6917	0.9500
F19	0.6917	0.6917	0.5000	0.8167	0.5000	0.6917	0.8167	0.8167	0.5000	0.9500
F20	0.8167	0.9500	0.6917	0.8167	0.6917	0.8167	0.9500	0.9500	0.8167	0.9500

Table 7: Part 2 of the crisp score matrix of expert 1

Code	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20
F1	0.6917	0.8167	0.3833	0.1667	0.6917	0.9500	0.8167	0.8167	0.8167	0.8167
F2	0.5000	0.9500	0.8167	0.6917	0.5000	0.3833	0.2750	0.3833	0.1667	0.3833
F3	0.5000	0.5000	0.2750	0.6917	0.8167	0.6917	0.6917	0.6917	0.6917	0.6917
F4	0.8167	0.5000	0.6917	0.3833	0.6917	0.8167	0.6917	0.6917	0.6917	0.6917
F5	0.3833	0.6917	0.8167	0.5000	0.9500	0.8167	0.6917	0.8167	0.5000	0.9500
F6	0.6917	0.3833	0.9500	0.6917	0.6917	0.6917	0.9500	0.6917	0.5000	0.9500
F7	0.9500	0.8167	0.8167	0.8167	0.5000	0.6917	0.8167	0.8167	0.8167	0.9500
F8	0.5000	0.5000	0.6917	0.6917	0.3833	0.5000	0.9500	0.9500	0.9500	0.9500
F9	0.8167	0.6917	0.5000	0.5000	0.6917	0.2750	0.6917	0.6917	0.6917	0.8167
F10	0.5000	0.5000	0.6917	0.6917	0.5000	0.3833	0.9500	0.9500	0.9500	0.9500
F11	0	0.5000	0.5000	0.2750	0.9500	0.8167	0.2750	0.5000	0.3833	0.5000
F12	0.3833	0	0.5000	0.6917	0.2750	0.6917	0.9500	0.8167	0.9500	0.9500
F13	0.5000	0.6917	0	0.8167	0.3833	0.1667	0.5000	0.5000	0.5000	0.5000
F14	0.5000	0.8167	0.5000	0	0.9500	0.5000	0.8167	0.6917	0.8167	0.8167
F15	0.8167	0.6917	0.5000	0.3833	0	0.2750	0.8167	0.6917	0.6917	0.8167
F16	0.2750	0.2750	0.6917	0.3833	0.8167	0	0.8167	0.5000	0.8167	0.6917
F17	0.5000	0.9500	0.5000	0.6917	0.6917	0.9500	0	0.9500	0.9500	0.8167
F18	0.5000	0.8167	0.5000	0.6917	0.6917	0.6917	0.6917	0	0.9500	0.9500
F19	0.5000	0.9500	0.5000	0.6917	0.6917	0.6917	0.9500	0.9500	0	0.5000
F20	0.6917	0.9500	0.5000	0.6917	0.9500	0.6917	0.6917	0.9500	0.5000	0

Table 8: Part 1 of the average direct relationship matrix

Code	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	0.0000	0.5000	0.6917	0.5000	0.5000	0.6917	0.5000	0.3833	0.6917	0.8167
F2	0.6917	0.0000	0.9500	0.6917	0.5000	0.8167	0.6917	0.5000	0.2750	0.2750
F3	0.8167	0.8167	0.0000	0.8167	0.6917	0.9500	0.6917	0.5000	0.6917	0.6917
F4	0.5000	0.9500	0.6917	0.0000	0.3833	0.5000	0.6917	0.3833	0.2750	0.6917
F5	0.6917	0.6917	0.5000	0.6917	0.0000	0.5000	0.6917	0.6917	0.6917	0.5000
F6	0.9500	0.5000	0.8167	0.6917	0.6917	0.0000	0.3833	0.6917	0.6917	0.5000
F7	0.8167	0.6917	0.5000	0.5000	0.5000	0.6917	0.0000	0.8167	0.8167	0.8167
F8	0.3833	0.5000	0.5000	0.5000	0.6917	0.5000	0.6917	0.0000	0.5000	0.9500
F9	0.5000	0.2750	0.5000	0.6917	0.6917	0.3833	0.5000	0.6917	0.0000	0.6917
F10	0.6917	0.6917	0.5000	0.8167	0.5000	0.2750	0.8167	0.3833	0.6917	0.0000
F11	0.9500	0.6917	0.8167	0.5000	0.8167	0.9500	0.6917	0.8167	0.8167	0.5000
F12	0.6917	0.8167	0.5000	0.5000	0.2750	0.8167	0.8167	0.2750	0.5000	0.5000
F13	0.5000	0.6917	0.6917	0.6917	0.6917	0.6917	0.8167	0.5000	0.2750	0.5000
F14	0.5000	0.5000	0.6917	0.9500	0.3833	0.3833	0.2750	0.9500	0.3833	0.9500
F15	0.6917	0.3833	0.5000	0.3833	0.6917	0.5000	0.1667	0.3833	0.5000	0.6917
F16	0.5000	0.5000	0.8167	0.6917	0.5000	0.3833	0.6917	0.2750	0.8167	0.5000
F17	0.9500	0.6917	0.5000	0.8611	0.5000	0.5000	0.8167	0.8167	0.5000	0.8000
F18	0.8167	0.6917	0.5000	0.8167	0.6917	0.6917	0.6917	0.8167	0.6917	0.9500
F19	0.6917	0.6917	0.5000	0.8167	0.5000	0.6917	0.8167	0.8167	0.5000	0.8000
F20	0.8611	0.9500	0.6917	0.8167	0.6917	0.8167	0.9500	0.9500	0.8167	0.9500

Table 9: Part 2 of the average direct relationship matrix

Code	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20
F1	0.6917	0.8167	0.3833	0.1667	0.6917	0.9500	0.8167	0.8167	0.8167	0.8611
F2	0.5000	0.9500	0.8167	0.6917	0.5000	0.3833	0.2750	0.3833	0.1667	0.3833
F3	0.5000	0.5000	0.2750	0.6917	0.8167	0.6917	0.6917	0.6917	0.6917	0.6917
F4	0.8167	0.5000	0.6917	0.3833	0.6917	0.8167	0.6917	0.6917	0.6917	0.6917

F5	0.3833	0.6917	0.8167	0.5000	0.9500	0.8167	0.6917	0.8167	0.5000	0.9500
F6	0.6917	0.3833	0.9500	0.6917	0.6917	0.6917	0.9500	0.6917	0.5000	0.9500
F7	0.9500	0.8167	0.8167	0.8167	0.5000	0.6917	0.8167	0.8167	0.8167	0.9500
F8	0.5000	0.5000	0.6917	0.6917	0.3833	0.5000	0.9500	0.9500	0.9500	0.9500
F9	0.8167	0.6917	0.5000	0.5000	0.6917	0.2750	0.6917	0.6917	0.6917	0.8167
F10	0.5000	0.5000	0.6917	0.6917	0.5000	0.3833	0.9500	0.9500	0.9500	0.9500
F11	0.0000	0.5000	0.5000	0.2750	0.9500	0.8167	0.2750	0.5000	0.3833	0.5000
F12	0.3833	0.0000	0.5000	0.6917	0.2750	0.6917	0.9500	0.8167	0.9500	0.9500
F13	0.5000	0.6917	0.0000	0.8167	0.3833	0.1667	0.5000	0.5000	0.4611	0.5000
F14	0.5000	0.8167	0.5000	0.0000	0.9500	0.5000	0.7111	0.6917	0.8167	0.8167
F15	0.8167	0.6917	0.5000	0.3833	0.0000	0.2750	0.8167	0.6917	0.6917	0.8611
F16	0.2750	0.2750	0.6917	0.3833	0.8167	0.0000	0.8167	0.5000	0.8167	0.6917
F17	0.5000	0.9500	0.5000	0.6917	0.6917	0.9500	0.0000	0.9500	0.9500	0.8167
F18	0.5000	0.8167	0.5000	0.6917	0.6917	0.6917	0.6917	0.0000	0.8000	0.9500
F19	0.5000	0.9500	0.5000	0.6917	0.6917	0.6917	0.9500	0.9500	0.0000	0.5000
F20	0.6917	0.9500	0.5000	0.6917	0.9500	0.6917	0.6917	0.9500	0.5000	0.0000

Table 10: Part 1 of the normalization matrix

Code	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	0.0000	0.0331	0.0458	0.0331	0.0331	0.0458	0.0331	0.0254	0.0458	0.0540
F2	0.0458	0.0000	0.0629	0.0458	0.0331	0.0540	0.0458	0.0331	0.0182	0.0182
F3	0.0540	0.0540	0.0000	0.0540	0.0458	0.0629	0.0458	0.0331	0.0458	0.0458
F4	0.0331	0.0629	0.0458	0.0000	0.0254	0.0331	0.0458	0.0254	0.0182	0.0458
F5	0.0458	0.0458	0.0331	0.0458	0.0000	0.0331	0.0458	0.0458	0.0458	0.0331
F6	0.0629	0.0331	0.0540	0.0458	0.0458	0.0000	0.0254	0.0458	0.0458	0.0331
F7	0.0540	0.0458	0.0331	0.0331	0.0331	0.0458	0.0000	0.0540	0.0540	0.0540
F8	0.0254	0.0331	0.0331	0.0331	0.0458	0.0331	0.0458	0.0000	0.0331	0.0629
F9	0.0331	0.0182	0.0331	0.0458	0.0458	0.0254	0.0331	0.0458	0.0000	0.0458

F10	0.0458	0.0458	0.0331	0.0540	0.0331	0.0182	0.0540	0.0254	0.0458	0.0000
F11	0.0629	0.0458	0.0540	0.0331	0.0540	0.0629	0.0458	0.0540	0.0540	0.0331
F12	0.0458	0.0540	0.0331	0.0331	0.0182	0.0540	0.0540	0.0182	0.0331	0.0331
F13	0.0331	0.0458	0.0458	0.0458	0.0458	0.0458	0.0540	0.0331	0.0182	0.0331
F14	0.0331	0.0331	0.0458	0.0629	0.0254	0.0254	0.0182	0.0629	0.0254	0.0629
F15	0.0458	0.0254	0.0331	0.0254	0.0458	0.0331	0.0110	0.0254	0.0331	0.0458
F16	0.0331	0.0331	0.0540	0.0458	0.0331	0.0254	0.0458	0.0182	0.0540	0.0331
F17	0.0629	0.0458	0.0331	0.0570	0.0331	0.0331	0.0540	0.0540	0.0331	0.0529
F18	0.0540	0.0458	0.0331	0.0540	0.0458	0.0458	0.0458	0.0540	0.0458	0.0629
F19	0.0458	0.0458	0.0331	0.0540	0.0331	0.0458	0.0540	0.0540	0.0331	0.0529
F20	0.0570	0.0629	0.0458	0.0540	0.0458	0.0540	0.0629	0.0629	0.0540	0.0629

Table 11: Part 2 of the normalization matrix

Code	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20
F1	0.0458	0.0540	0.0254	0.0110	0.0458	0.0629	0.0540	0.0540	0.0540	0.0570
F2	0.0331	0.0629	0.0540	0.0458	0.0331	0.0254	0.0182	0.0254	0.0110	0.0254
F3	0.0331	0.0331	0.0182	0.0458	0.0540	0.0458	0.0458	0.0458	0.0458	0.0458
F4	0.0540	0.0331	0.0458	0.0254	0.0458	0.0540	0.0458	0.0458	0.0458	0.0458
F5	0.0254	0.0458	0.0540	0.0331	0.0629	0.0540	0.0458	0.0540	0.0331	0.0629
F6	0.0458	0.0254	0.0629	0.0458	0.0458	0.0458	0.0629	0.0458	0.0331	0.0629
F7	0.0629	0.0540	0.0540	0.0540	0.0331	0.0458	0.0540	0.0540	0.0540	0.0629
F8	0.0331	0.0331	0.0458	0.0458	0.0254	0.0331	0.0629	0.0629	0.0629	0.0629
F9	0.0540	0.0458	0.0331	0.0331	0.0458	0.0182	0.0458	0.0458	0.0458	0.0540
F10	0.0331	0.0331	0.0458	0.0458	0.0331	0.0254	0.0629	0.0629	0.0629	0.0629
F11	0.0000	0.0331	0.0331	0.0182	0.0629	0.0540	0.0182	0.0331	0.0254	0.0331
F12	0.0254	0.0000	0.0331	0.0458	0.0182	0.0458	0.0629	0.0540	0.0629	0.0629

F13	0.0331	0.0458	0.0000	0.0540	0.0254	0.0110	0.0331	0.0331	0.0305	0.0331
F14	0.0331	0.0540	0.0331	0.0000	0.0629	0.0331	0.0471	0.0458	0.0540	0.0540
F15	0.0540	0.0458	0.0331	0.0254	0.0000	0.0182	0.0540	0.0458	0.0458	0.0570
F16	0.0182	0.0182	0.0458	0.0254	0.0540	0.0000	0.0540	0.0331	0.0540	0.0458
F17	0.0331	0.0629	0.0331	0.0458	0.0458	0.0629	0.0000	0.0629	0.0629	0.0540
F18	0.0331	0.0540	0.0331	0.0458	0.0458	0.0458	0.0458	0.0000	0.0529	0.0629
F19	0.0331	0.0629	0.0331	0.0458	0.0458	0.0458	0.0629	0.0629	0.0000	0.0331
F20	0.0458	0.0629	0.0331	0.0458	0.0629	0.0458	0.0458	0.0629	0.0331	0.0000

Table 12: Part 1 of the total relationship matrix

Code	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	0.2061	0.2233	0.2266	0.2324	0.2010	0.2266	0.2264	0.2053	0.2185	0.2548
F2	0.2170	0.1619	0.2151	0.2123	0.1743	0.2071	0.2064	0.1837	0.1641	0.1894
F3	0.2658	0.2503	0.1915	0.2606	0.2198	0.2496	0.2446	0.2209	0.2250	0.2564
F4	0.2274	0.2414	0.2184	0.1900	0.1852	0.2063	0.2279	0.1961	0.1828	0.2361
F5	0.2544	0.2402	0.2204	0.2495	0.1738	0.2198	0.2428	0.2295	0.2220	0.2420
F6	0.2767	0.2343	0.2457	0.2563	0.2233	0.1934	0.2298	0.2357	0.2274	0.2485
F7	0.2856	0.2617	0.2413	0.2610	0.2250	0.2524	0.2214	0.2589	0.2496	0.2844
F8	0.2323	0.2257	0.2159	0.2356	0.2140	0.2158	0.2404	0.1843	0.2071	0.2664
F9	0.2219	0.1955	0.2004	0.2287	0.2001	0.1938	0.2114	0.2118	0.1605	0.2330
F10	0.2524	0.2388	0.2176	0.2558	0.2031	0.2040	0.2489	0.2102	0.2194	0.2083
F11	0.2609	0.2301	0.2318	0.2275	0.2184	0.2391	0.2324	0.2279	0.2229	0.2314
F12	0.2452	0.2386	0.2115	0.2290	0.1825	0.2304	0.2411	0.1965	0.2017	0.2318
F13	0.2097	0.2098	0.2023	0.2171	0.1892	0.2024	0.2184	0.1890	0.1674	0.2080
F14	0.2353	0.2226	0.2249	0.2586	0.1922	0.2058	0.2110	0.2385	0.1962	0.2630

F15	0.2238	0.1921	0.1914	0.1999	0.1915	0.1920	0.1812	0.1834	0.1838	0.2217
F16	0.2147	0.2022	0.2140	0.2226	0.1825	0.1872	0.2160	0.1795	0.2056	0.2139
F17	0.2897	0.2590	0.2378	0.2793	0.2210	0.2372	0.2695	0.2543	0.2272	0.2805
F18	0.2780	0.2554	0.2345	0.2731	0.2301	0.2452	0.2582	0.2515	0.2357	0.2856
F19	0.2635	0.2486	0.2278	0.2659	0.2120	0.2389	0.2587	0.2449	0.2174	0.2692
F20	0.3023	0.2903	0.2653	0.2931	0.2480	0.2722	0.2930	0.2778	0.2614	0.3061

Table 13: Part 2 of the total relationship matrix

Code	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20
F1	0.2152	0.2538	0.1994	0.1852	0.2416	0.2430	0.2676	0.2699	0.2561	0.2817
F2	0.1773	0.2299	0.1994	0.1909	0.1983	0.1794	0.2003	0.2082	0.1838	0.2174
F3	0.2121	0.2438	0.2015	0.2246	0.2584	0.2351	0.2692	0.2715	0.2568	0.2818
F4	0.2142	0.2245	0.2099	0.1899	0.2312	0.2247	0.2471	0.2497	0.2365	0.2583
F5	0.2020	0.2529	0.2315	0.2110	0.2625	0.2387	0.2657	0.2758	0.2424	0.2939
F6	0.2257	0.2399	0.2440	0.2272	0.2541	0.2376	0.2872	0.2748	0.2482	0.3002
F7	0.2554	0.2833	0.2508	0.2500	0.2576	0.2523	0.2973	0.3007	0.2847	0.3190
F8	0.2048	0.2380	0.2203	0.2207	0.2245	0.2166	0.2774	0.2809	0.2663	0.2893
F9	0.2105	0.2316	0.1932	0.1925	0.2267	0.1877	0.2432	0.2465	0.2331	0.2622
F10	0.2072	0.2404	0.2209	0.2210	0.2330	0.2111	0.2780	0.2818	0.2672	0.2901
F11	0.1696	0.2299	0.2047	0.1879	0.2539	0.2306	0.2307	0.2459	0.2250	0.2565
F12	0.1928	0.1998	0.2031	0.2147	0.2116	0.2234	0.2704	0.2649	0.2591	0.2814
F13	0.1808	0.2195	0.1518	0.2026	0.1955	0.1701	0.2182	0.2206	0.2058	0.2291
F14	0.2024	0.2527	0.2051	0.1728	0.2552	0.2133	0.2602	0.2616	0.2556	0.2776
F15	0.2009	0.2214	0.1837	0.1761	0.1731	0.1787	0.2393	0.2349	0.2218	0.2527
F16	0.1721	0.1997	0.1990	0.1799	0.2278	0.1622	0.2434	0.2266	0.2333	0.2459
F17	0.2251	0.2880	0.2288	0.2392	0.2654	0.2657	0.2437	0.3056	0.2907	0.3078

F18	0.2224	0.2761	0.2260	0.2362	0.2622	0.2462	0.2834	0.2425	0.2772	0.3119
F19	0.2160	0.2769	0.2199	0.2305	0.2544	0.2401	0.2914	0.2938	0.2205	0.2770
F20	0.2523	0.3047	0.2444	0.2541	0.2978	0.2647	0.3052	0.3236	0.2801	0.2766

Table 14: Summation of TRM rows and columns

Code	R	C	R+C	R-C
F1	4.6345	4.9626	9.5971	-0.3281
F2	3.9161	4.6217	8.5378	-0.7056
F3	4.8394	4.4342	9.2736	0.4052
F4	4.3978	4.8484	9.2462	-0.4506
F5	4.7707	4.0868	8.8575	0.6839
F6	4.9099	4.4193	9.3292	0.4907
F7	5.2925	4.6792	9.9717	0.6133
F8	4.6761	4.3798	9.0558	0.2963
F9	4.2840	4.1954	8.4794	0.0885
F10	4.7089	4.9304	9.6393	-0.2216
F11	4.5571	4.1589	8.7159	0.3982
F12	4.5296	4.9068	9.4364	-0.3772
F13	4.0072	4.2374	8.2446	-0.2302
F14	4.6044	4.2068	8.8112	0.3976
F15	4.0431	4.7850	8.8281	-0.7419
F16	4.1280	4.4211	8.5492	-0.2931
F17	5.2154	5.2186	10.4340	-0.0032
F18	5.1313	5.2797	10.4110	-0.1483

F19	4.9675	4.9441	9.9116	0.0234
F20	5.6130	5.5102	11.1232	0.1027

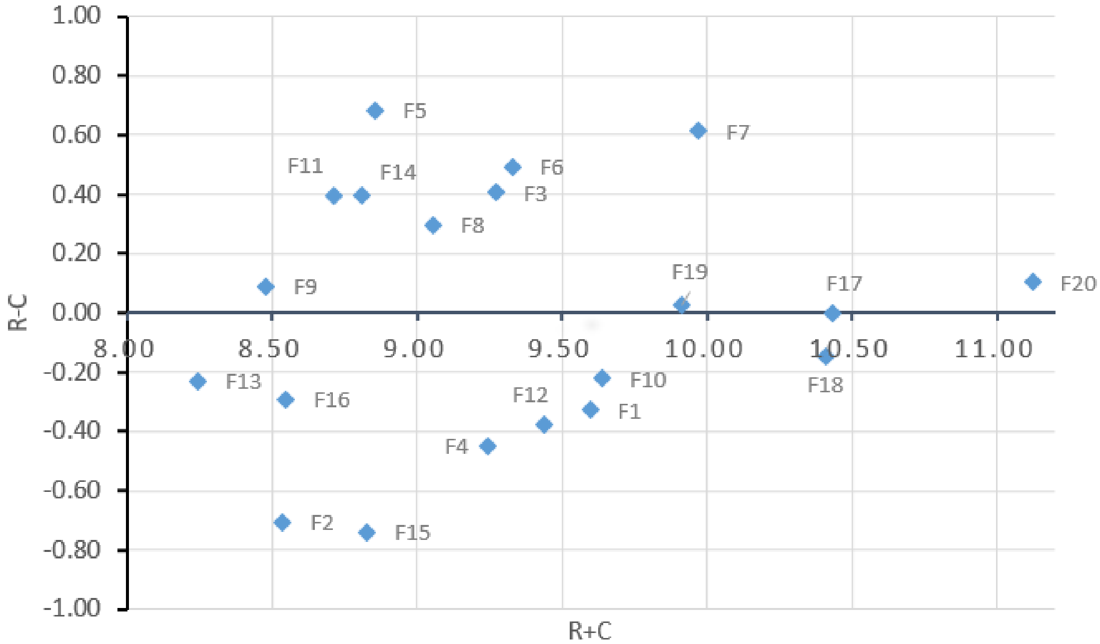

Figure 2: Causal diagram

5. Results and Discussions

This study aims to identify and rank the key elements in GSCM systems that are enabled by the Internet of Things. We have chosen 20 CSFs from the literature review that we felt were pertinent to our issue. Following the identification of these 20 CSFs, the Neutrosophic DEMATEL method—regarded as an effective MCDM tool—was used to organize them into cause- and effect-related categories. It has the capacity to convert the intricate relationships between the requirements of real-world problems into an easily understandable, structured model. The outcome drawn by using the suggested model to analyze data gathered from the chosen experts.

5.1 Ranking of the CSFs

The ranking was carried out based on R+C values presented in table 13. It is clear that the Big Data and BDA tools (F20) was the most critical factor with the highest importance value of 11.1232, while creation of highly qualified and competent human labor (F13) with of value of 8.2446 is the least influent CSF of the 20 selected ones. The influence degree for all CSFs included in the calculation are presented in Table 14. We recommend that the organizations should concentrate on these crucial CSFs, and once IoT-enabled GSCM implementation has reached the appropriate level, the implementation procedure will be adjusted. The degree of implementation will now be raised through a continual improvement process, with the least important CSFs being attended to in accordance with their importance. For more clarification of the results, Figure 3 visualizes the importance ranking of the CSFs.

5.2 Cause/effect grouping of the CSFs

According to the R-C values, the CSFs were classified into cause and effect groups (Table 15). Ten CSFs (F20, F7, F19, F6, F3, F8, F5, F14, F11, and F9) were recognized to be in the cause group and rest ten CSFs (F17, F18, F10, F1, F12, F4, F15, F16, F2, and F13) were recognized to be in the effect group. This analysis showed that F5 is the most influencing CSF, which has the greatest R-C value of 0.6839, while the most influenced CSF is discovered to be F15, which has the lowest R-C value of minus 0.7419.

5.3 CSFs Interactions

Due to the case scenario's consideration of 20 CSFs, it was challenging to depict all CSF interactions on an Impact Relationship Map (IRM). In order to see how each CSF interacts with other CSFs (both influencing and being impacted), the IRM for each CSF has been constructed based on the threshold (▽) that is calculated using the following expression:

$$\triangledown = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} TRM_{i,j}}{N*N} \tag{10}$$

Despite the fact that IRMs have been created for all CSFs, only the IRM for the F16 AMB is displayed in Figure 4 as an example. Each CSF influences and is influenced by a variety of other CSFs. Table 16 shows the full interactions among all CSFs.

Table 15: CSFs importance ranking with related cause/effect grouping

CSF	Code	$Ri + Cj$	Importance rank	$Ri - Cj$	Cause	Effect
Big Data and Big Data Analytics (BDA) tools	F20	11.1232	1	0.1027	√	
RFID and GPS	F17	10.4340	2	-0.0032		√
Cloud computing and IoT applications	F18	10.4110	3	-0.1483		√
Top management commitment	F7	9.9717	4	0.6133	√	
Sensor technologies and sensor network	F19	9.9116	5	0.0234	√	
Green marketing	F10	9.6393	6	-0.2216		√
Influence from investors and stakeholders	F1	9.5971	7	-0.3281		√
Reverse logistics	F12	9.4364	8	-0.3772		√
Green packaging and transportation	F6	9.3292	9	0.4907	√	
Environmental regulations	F3	9.2736	10	0.4052	√	

Global competitive advantage	F4	9.2462	11	-0.4506		√
Greening competition pressures	F8	9.0558	12	0.2963	√	
Management of toxic/ harmful/ hazardous materials and waste and pollution preventative measures	F5	8.8575	13	0.6839	√	
Collaboration with suppliers	F15	8.8281	14	-0.7419		√
green practices, policies, and infrastructure	F14	8.8112	15	0.3976	√	
Standards and regulations (ISO 14000)	F11	8.7159	16	0.3982	√	
Recycling and lifecycle management	F16	8.5492	17	-0.2931		√
Waste management	F2	8.5378	18	-0.7056		√
power negotiations along the supply chain	F9	8.4794	19	0.0885	√	
creation of highly qualified and competent human labor	F13	8.2446	20	-0.2302		√

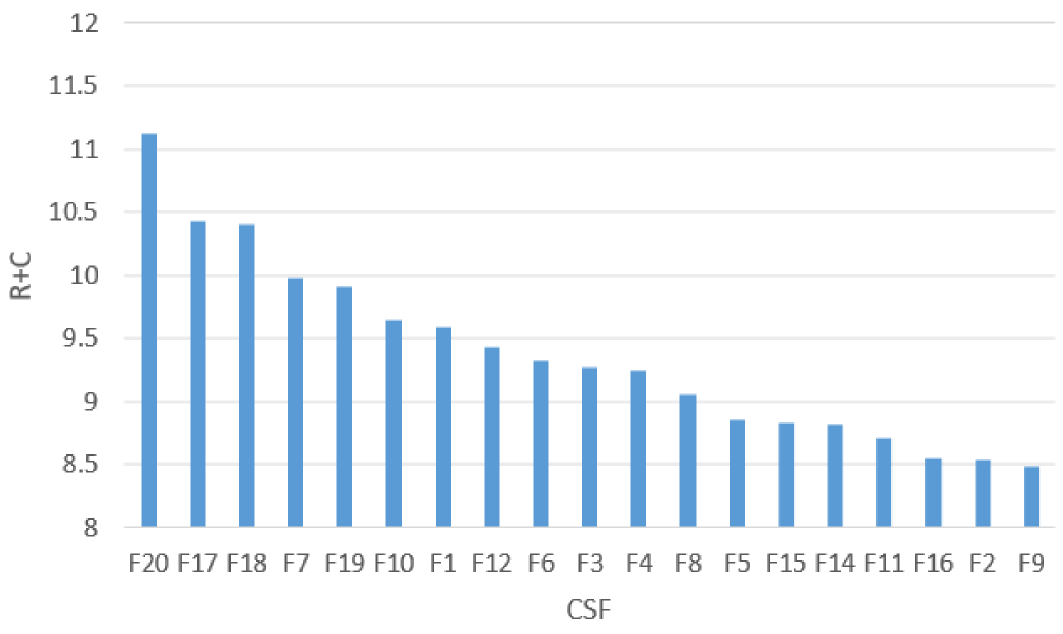

Figure 3: CSFs importance ranking

Table 16: CSFs interactions

CSF	influencing	influenced
F1	F11,F13,F16,F17,F18,F19,F20	F3,F5,F6,F7,F10,F11,F12,F14,F17,F18,F19,F20
F2	--	F3,F4,F5,F6,F7,F10,F12,F17,F18,F19,F20
F3	F1,F2,F4,F6,F7,F10,F11,F13,F16,F17,F18,F19,F20	F6,F7,F17,F18,F20
F4	F2,F11,F18,F19,F20	F3,F5,F6,F7,F8,F14,F17,F18,F19,F20
F5	F1,F2,F4,F7,F10,F11,F13,F16,F17,F18,F19,F20	F20
F6	F1,F2,F3,F4,F8,F10,F11,F13,F14,F16,F17,F18,F19,F20	F3,F7,F11,F17,F18,F19,F20
F7	F1,F2,F3,F4,F6,F8,F9,F10,F11,F12,F13,F14,F15,F16,F17, F18,F19,F20	F3,F5,F8,F10,F12,F17,F18,F19,F20
F8	F4,F7,F11,F13,F18,F19,F20	F6,F7,F14,F17,F18,F19,F20
F9	F18,F19	F7,F18,F20
F10	F1,F2,F4,F7,F10,F13,F18,F19,F20	F3,F5,F6,F7,F10,F11,F12,F14,F17,F18,F19,F20
F11	F1,F6,F10,F16,F19	F1,F3,F4,F5,F6,F7,F8,F14,F17,F18,F19,F20
F12	F1,F2,F7,F10,F18,F19,F20	F7,F20
F13	--	F1,F3,F5,F6,F7,F8,F10,F14,F17,F18,F19,F20
F14	F1,F4,F8,F10,F11,F13,F16,F18,F19,F20	F6,F7,F20
F15	F18,F19	F7,F17,F18,F20
F16	F18,F20	F1,F3,F5,F6,F7,F11,F14,F17,F18,F19,F20
F17	F1,F2,F3,F4,F6,F7,F8,F10,F11,F13,F15,F16,F17,F18,F19, F20	F1,F3,F5,F6,F7,F17,F18,F19,F20
F18	F1,F2,F3,F4,F6,F7,F8,F9,F10,F11,F13,F15,F16,F17,F18, F19,F20	F1,F3,F4,F5,F6,F7,F8,F9,F10,F12,F14,F15,F16, F17,F18,F19,F20
F19	F1,F2,F4,F6,F7,F8,F10,F11,F13,F16,F17,F18,F19	F1,F3,F4,F5,F6,F7,F8,F9,F10,F11,F12,F14,F15, F17,F18,F19,F20
F20	F1,F2,F3,F4,F5,F6,F7,F8,F9,F10,F11,F12,F13,F14,F15, F16,F17,F18,F19,F20	F1,F3,F5,F6,F7,F8,F10,F12,F14,F16,F17,F18,F20

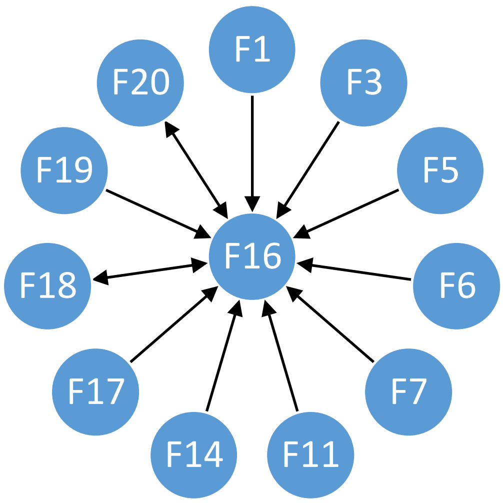

Figure 4: F16 interactions with other CSFs

6. Conclusion

Poor strategic planning, ineffective management, and poor information management all contribute to weak core competencies and poor information awareness in the manufacturing operation. It is evident that by concentrating more on the root causes of an issue and efficiently manage the effects can enhance system performance and productivity. The similar theory was used in IoT-enabled GSCM environments using neutrosophic DEMATEL method to prioritize the CSFs responsible for the company's performance. Green supply chain management has been viewed as a key component of firms' efforts to improve their performance. As a result, the focus of this study was to investigate the crucial success criteria needed for the management of green supply chains that are enabled by IoT technology. A survey of the literature led to the discovery of 20 CSFs categorized into two groups: green enablers and IoT enablers. After applying the neutrosophic DEMATEL approach, we identified the relative importance of each factor, the Cause/effect grouping, and the how each CSF influence/influenced by other CSFs. Finally, we recommended that the organizations should concentrate on selected CSFs, and once IoT-enabled GSCM implementation has reached the appropriate level, the implementation procedure will be adjusted. The degree of implementation will now be raised through a continual improvement process, with the least important CSFs being attended to in accordance with their importance.

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