
14.0 ADOPTION: SUPPLY CHAIN RESILIENCE AND SUSTAINABILITY

5.1 Introduction

Supply Chain Resilience & Sustainability (SCRS) refers to the characteristics such as adaptability to change and readiness to recover from disruptions and unexpected events in a way, which is sustainable. It makes supply chains able to continue operating even in the face of unforeseen disruptions by promptly recognizing and mitigating their effects, locating alternate sources of supply, enhancing the utilization of resources, and adapting to changes in demand. SCRS reduces the likelihood that supply chains will be disrupted by events like natural disasters, political unrest, and economic downturns, ensuring company continuity. In addition, governments are also implementing more regulations to make sure businesses function sustainability and firms can escape legal repercussions and guarantee adherence to environmental and social standards by implementing SCRS practices. With the increasing complexity and involvement of numerous parties in supply chains, it has become imperative for stakeholders to possess qualities such as transparency, traceability, security, resilience, and sustainability in order to tackle the challenges arising from the daily surge in demand. In addition, the supply chain processes need a simple, efficient, and secure environment to conduct various business transactions with efficient and correct information flow to maintain resilience and sustainability (Sawyer & Harrison, 2020).

Increasing complexity and the involvement of additional stakeholders make it impossible to predict the impact of each decision, which puts supply chain managers in uncertain situations. However, a supply chain that can adapt and react to the current scenario gives them some control over these ambiguous circumstances. These characteristics of sensing disturbances or threats and giving appropriate responses can be improved with the implementation of blockchain-enabled technologies and can prove critical to the success of supply chain resilience and sustainability.

5.2 Methodology

This study has identified twenty-one blockchain technology-enabled critical success factors for supply chain resilience and sustainability and grey theory is used to address the limitation of data availability. Applications of BT can be included in the supply chain to improve its resilience and recovery capacities as well as make it sustainable and prepared for unforeseen obstacles. The considered supply chain includes suppliers, manufacturers, logistics (inbound and outbound), and customers, to have a better grasp of SCRS. The literature review is carried out with the aforementioned components of the supply chain in mind, and the identified BT-enabled Critical Success Factors (CSF) for SCRS are sorted into four categories. 1. Manufacturer, 2 suppliers, 3. Logistics and 4. Customers. The specification of experts is given in Table 9.

Table 9: Specification of experts

Respondents Types	For screening criteria	Average Work Experience (Years)	To identify the interrelations	Average Work Experience (Years)
Industry Expert	30	5.5	3	8
Academicians	80	6.0	1	12
Research Scholar	95	2.0	-	-

A questionnaire is circulated and 230 responses are received out of that 205 are selected for screening criteria. To identify the interrelations among BT-enabled CSFs for SCRS a panel of 4 members is selected and the Delphi technique is employed. The responses are collected and analyzed after every round and a summary is presented to experts. The process continued until a consensus was reached among experts. The proposed research framework to examine the causal relationship among BT-enabled CSFs for SCRS is shown in Figure 8.

Twenty-one BT-enabled Critical Success Factors (CSF) for SCRS are identified and presented in Table 10. These factors have been discussed by many researchers in a wide range of applications. Smart contracts concerning BT and BT-enabled integration of the supply chain to enhance visibility, trust, and resilience are widely considered and discussed by most researchers (Khanfar et al., 2021; Kim & Shin, 2019 Bayramova et al., 2021; S. S. Kamble et al., 2021; Li et al., 2021).

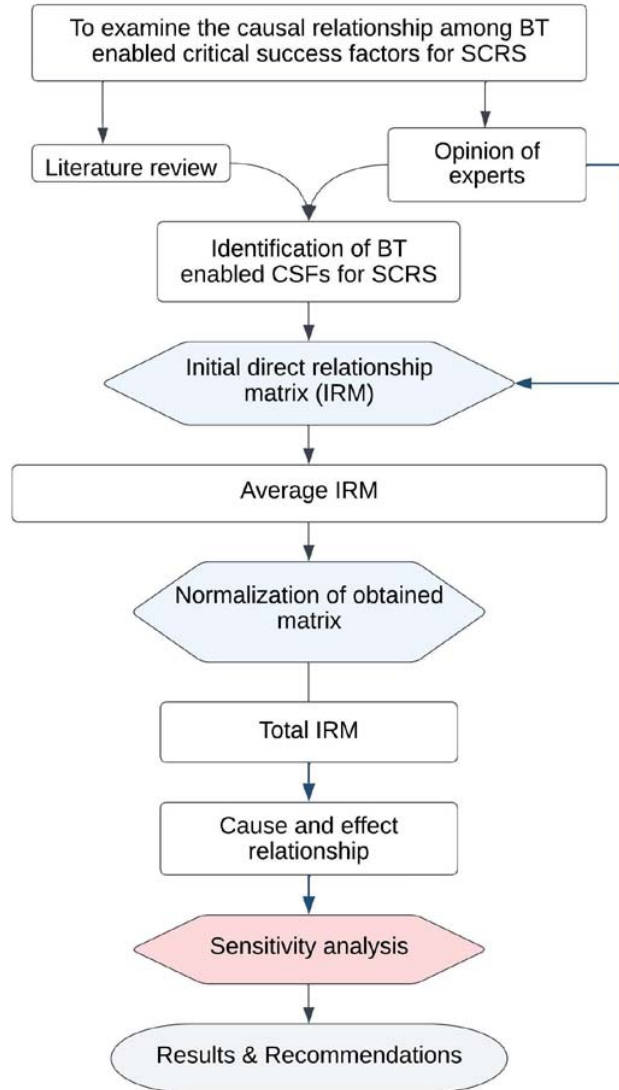


Figure 8: Proposed research framework

Table 10: BT-enabled Critical Success Factors for SCRS.

Group	Sl no	Critical Success Factors (CSF)	Description	References
Supplier	1	Smart Contract (SC)	Digital contract management, execution, or verification. There is no requirement for intermediaries to complete the transactions because smart contracts function on the blockchain network, which handles every	(Khanfar et al., 2021b; Kim & Shin, 2019b; Lohmer et al., 2020; Yousefi & Mohamadpour Tosarkani, 2022)

			transaction in a contract. They offer a more efficient, affordable, and secure approach to managing and carrying out agreements.	
	2	Internal Integration (IN)	By combining serial numbers, bar codes, sensors, and digital tags, BT creates a unified and transparent platform that uses a distributed database to make it easier to regulate internal processes.	(Bayramova et al., 2021; S. S. Kamble et al., 2021b; Li et al., 2021b; Lohmer et al., 2020)
	3	Structured Operating guidelines/parameters (SOG)	The operational standards and parameters are made more understandable and accessible due to BT's assistance in standardizing document management.	(S. S. Kamble et al., 2021b)
	4	Supplier Integration (SI)	BT provides a replica of the network at every node, making data transparent to stakeholders. In this instance, all transactions are consensually based to promote openness and confidence.	(S. S. Kamble et al., 2021b; Li et al., 2021a)
Manufacturer	5	Inventory Management (IM)	By logging any purchase order and providing a copy of the data available to the stockholders utilizing its distributed nature, BT makes inventory management inside SCs easier.	(S. S. Kamble et al., 2021b; Lohmer et al., 2020)
	6	Supplier and Raw material Verification (SRV)	To lessen the likelihood of data manipulation and forgeries, BT logs every transaction and flow of data following confirmation in SCs and does not permit editing, tampering, or change.	(S. S. Kamble et al., 2021b)

	7	BT-enabled Daily Operations (BDO)	Using data properties inherent in transactions, BT reduces needless stages in the settlement process and the requirement for clearance by outside organizations along with that it helps streamline the daily routine operations of the firm.	(S. S. Kamble et al., 2021b; Min, 2019)
	8	Manufacturing Parameter Validation (MPV)	The BT can be used for production parameter validation because of its immutability.	(S. S. Kamble et al., 2021b)
	9	Revenue management system for the employee (RMS)	Due to the secure and transparent nature of BT, it can be used for efficient revenue-sharing methods.	(S. S. Kamble et al., 2021b)
	10	Quality data for Forecasting and Analytics (QDF)	BT ensures the quality of the data it offers by keeping a record of transaction history, ensuring the integrity of the information, and making every transaction transparent to all stakeholders.	(Kumar Bhardwaj et al., 2021)
	11	Organizational Archive for sensitive data/designs/plans (OA)	The level of security in BT is the best, which is why it is the perfect option for storing sensitive data/designs/plans.	(Alazab et al., 2021)
Logistics	12	Standardized Data Management (SD)	BT creates an immutable audit log to capture the data transaction after verification in supply chains. To reduce the possibility of data being manipulated or falsified, BT also forbids modification or tampering.	(Kumar Bhardwaj et al., 2021)

	13	Efficient Logistics (Verification and Validation) (EL)	The BT gives its approval to and provides support for transactions and document exchanges depending on the terms that parties have agreed upon. This helps with compliance with other rules as well as improving logistics processes by removing bottlenecks.	(S. S. Kamble et al., 2021b; Min, 2019)
	14	Efficient Intra-Organizational Communication (EIC)	BT facilitates more streamlined and automated communication between entities while maintaining the highest possible level of trust.	(S. S. Kamble et al., 2021b; Lohmer et al., 2020)
	15	Integration of Strategic Partners (ISP)	The distributed nature of BT allows it to share the information flow regarding ongoing processes from the beginning to the end, giving the required supply chain entities on blockchain access to data free from bias and error.	(Bayramova et al., 2021; S. S. Kamble et al., 2021b; Li et al., 2021b; Lohmer et al., 2020)
	16	Invoicing (validation and approval) (INV)	By implementing a distributed system, BT lessens the possibility of late payments and ineffective asset management while speeding up the conclusion of the transaction process.	(Agi & Jha, 2022; Jiang et al., 2022)
	17	Assets Tracking (such as resources and products) (AT)	Traceability of assets can be made easier by high-performance data records, distributed databases, and regulated user accesses.	(Bayramova et al., 2021; S. S. Kamble et al., 2021b; Min, 2019)
Customers	18	Smart Ordering (SO)	BT can help participants manage the orders more effectively by helping them keep track of data like pricing, dates, location,	(Bayramova et al., 2021; S. S. Kamble et al., 2021b)

			quality, certifications, and other important factors.	
	19	Efficient Financial Transactions (EFT)	BT uses smart contract-driven trade transactions to exchange assets in SCs, eliminating intermediaries and lowering transaction costs in the process.	(Agi & Jha, 2022; Jiang et al., 2022; Min, 2019)
	20	Standardized Document Management (SDM)	To keep the standard documents in good working order, standard tools, processes, and performance measure indicators are used.	(Agi & Jha, 2022; Kumar Bhardwaj et al., 2021)
	21	Customer Integration (CI)	By keeping track of each purchase order and making a copy of the information accessible to stockholders due to its distributed nature, BT facilitates customer integration among SCs.	(Agi & Jha, 2022; S. S. Kamble et al., 2021b; Li et al., 2021b)

5.2.1 Steps of the Grey-DEMATEL approach

The procedure for the grey DEMATEL method is broken down into the following steps, which are detailed below:

Step 1- Development of Initial Relationship Matrix (IRM)

The initial relationship matrix is formulated based on impact ratings from the respondents. The responses are collected based on the linguistic scale given in Table 11 and each respondent ‘k’ assessed the direct impact of factor ‘m’ over factor ‘n’. Let’s say ‘i’ represents the number of BT-enabled CSFs and ‘j’ is the selected number of respondents for the study. Thus, a total of ‘j’ initial relation matrices are constructed based on the impact parameters. The linguistic scale and associated grey values are presented in Table 11.

Step 2- Computation of Grey Matrix corresponding to each IRM

By specifying a higher and lower range of values as indicated in linguistic scale table 4, the matching grey matrices are produced from the values acquired in step 1 (Gupta & Barua, 2018b; Julong, 1989).

$$\otimes G_{mn}^k = \otimes \geq _G_{mn}^k, \overline{\otimes} G_{mn}^k \quad (1)$$

Where $1 \leq k \leq j$; $1 \leq m \leq i$; $1 \leq n \leq i$.

The IRMs are modified into grey relation matrices as per the obtained grey values, i.e. $[\otimes G_{mn}^1], [\otimes G_{mn}^2], \dots, [\otimes G_{mn}^j]$ (Rajesh & Ravi, 2015).

Table 11: Linguistic assessment and associated grey values.

Linguistic assessment	Intensity of Impact	Associated grey values
No Impact	0	(0.0,0.1)
Very low impact	1	(0.1,0.3)
low impact	2	(0.2,0.5)
Moderate Impact	3	(0.4,0.7)
High impact	4	(0.6,0.9)
Very high impact	5	(0.9,1.0)

Step 3- Average Grey Relation Matrices

The computation of the average grey relation matrix $[\otimes G_{mn}^l]$; $k = 1 - j$ is performed using 'j' grey relation matrices,

$$\otimes \tilde{G}_{mn} = \left(\frac{\sum_k \otimes G_{mn}^k}{j}, \frac{\sum_l \bar{\otimes} G_{mn}^k}{j} \right) \quad (2)$$

Step 4- Computation of crisp matrices from average grey matrices

By using a three-step, modified converting fuzzy values into crisp scores approach, the grey values are transformed into crisp values as follows (Julong, 1989; Rajesh & Ravi, 2015; Xia et al., 2015).

(i) Grey value normalization

$$\underline{\otimes} \tilde{G}_{mn} = (\underline{\otimes} \tilde{G}_{mn} - \min_n \underline{\otimes} \tilde{G}_{mn}) / \Delta_{min}^{max} \quad (3)$$

Where $\underline{\otimes} \tilde{G}_{mn}$ represents the value of the normalized lower limit for the grey number

$$\otimes \tilde{G}_{mn}$$

$$\bar{\otimes} \hat{G}_{mn} = (\bar{\otimes} \tilde{G}_{mn} - \min_n \bar{\otimes} \tilde{G}_{mn}) / \Delta_{min}^{max} \quad (4)$$

Where $\bar{\otimes} \hat{G}_{mn}$ represents the value of the normalized upper limit for the grey number

$$\otimes \tilde{G}_{mn}, \text{ and}$$

$$\Delta_{min}^{max} = \max_n \bar{\otimes} \tilde{G}_{mn} - \min_n \underline{\otimes} \tilde{G}_{mn} \quad (5)$$

(ii) Computation of total normalized crisp value

$$z_{mn} = \left(\frac{(\underline{\otimes} G_{mn}(1-\underline{\otimes} \dot{G}_{mn})+(\overline{\otimes} \dot{G}_{mn} \times \overline{\otimes} \dot{G}_{mn}))}{(1-\underline{\otimes} \dot{G}_{mn}+\overline{\otimes} \dot{G}_{mn})} \right) \quad (6)$$

(iii) Calculation of the final crisp values

$$z_{mn}^* = (\min \underline{\otimes} \tilde{G}_{mn} + z_{mn} \times \Delta_{\min}^{max}) \quad (7)$$

and,

$$Z = [z_{mn}^*] \quad (8)$$

Step 5- computation of the normalized direct crisp matrix

By calculating B and multiplying the average relation matrix Z by B, the normalized direct crisp relation matrix, A, is created i.e.

$$B = \frac{1}{\max_{1 \leq m \leq i \leq n} \sum_i z_{mn}^*} \quad (9)$$

And

$$A = Z \times B \quad (10)$$

Each element of matrix A ranges from 0 to 1.

Step 6- Computation of total relation matrix T_R

$$T_R = A \times (I - A)^{-1} \quad (11)$$

Where I represent the identity matrix.

Step 7- Cause and effect parameters

Let R_m be the sum of rows, C_n is the sum of columns, and t_{mn} represents the elements in the total relation matrix. Thus, using equations (12) and (13), it can be calculated as:

$$R_m = \sum_{n=1}^l t_{mn} \forall m \quad (12)$$

$$C_n = \sum_{m=1}^l t_{mn} \forall n \quad (13)$$

Step 8- Threshold setup and graph plotting

With the help of values obtained from equations (12) and (13), a causal diagram can be plotted.

5.2.2 Application of the proposed method

The stepwise application of the proposed model is presented below:

Step 1- In this step, the twenty-one BT-enabled critical success factors are identified through a literature review, and a detailed questionnaire is circulated among industry experts, researchers, and academicians to obtain the responses. A group of four experts (table 3) has been used to

identify the interrelations and direct impact among twenty-one BT-enabled CSFs. The experts used a linguistic scale to evaluate the impact of one BT-enabled CSFs over another. The used linguistic scale is presented in Table 11. Based on the opinion of experts four 21×21 direct relation matrices are developed.

Step 2- The obtained expert matrices are converted to initial grey relation matrices as per the scale given in Table 11.

Step 3- By using four grey relation matrices the average grey relation matrix Z is computed. This matrix is shown in table 12.

Table 12: Average Grey relation matrix for BT-enabled CSFs for SCRS

BD	MP	RM	OD	OA	SD	EL	EIC	ISP	INV	AT	SO	EFT	SD	CI
0.32	0.12	0.15	0.4	0.3	0.45	0.47	0.22	0.45	0.4	0.2	0.3	0.4	0.35	0.35
0.55	0.35	0.3	0.7	0.6	0.75	0.72	0.45	0.75	0.7	0.5	0.6	0.7	0.65	0.65
0.7	0.07	0.25	0.15	0.2	0.2	0.07	0.7	0.12	0.1	0.1	0.25	0.15	0.35	0.17
0.9	0.25	0.5	0.4	0.5	0.5	0.25	0.9	0.35	0.3	0.3	0.5	0.4	0.65	0.45
0.27	0.07	0.1	0.12	0.6	0.45	0.15	0.4	0.37	0.17	0.1	0.15	0.25	0.57	0.4
0.55	0.25	0.25	0.35	0.9	0.75	0.35	0.7	0.65	0.45	0.3	0.4	0.5	0.82	0.7
0.22	0.12	0.05	0.55	0.2	0.2	0.5	0.15	0.67	0.25	0.2	0.4	0.2	0.4	0.3
0.45	0.35	0.2	0.85	0.5	0.5	0.8	0.4	0.92	0.55	0.5	0.7	0.5	0.7	0.6
0.65	0.37	0.02	0.67	0.3	0.52	0.9	0.3	0.55	0.25	0.6	0.75	0.3	0.5	0.7
0.85	0.65	0.15	0.92	0.6	0.77	1	0.6	0.85	0.55	0.9	0.95	0.6	0.8	0.9
0.32	0.32	0.02	0.32	0.2	0.35	0.2	0.3	0.32	0.3	0.1	0.25	0.1	0.45	0.45
0.55	0.6	0.15	0.6	0.5	0.65	0.5	0.6	0.6	0.6	0.3	0.55	0.3	0.75	0.75
0	0.25	0.22	0.37	0.55	0.5	0.3	0.77	0.25	0.25	0.35	0.47	0.5	0.55	0.6
0.1	0.5	0.5	0.62	0.85	0.8	0.6	0.92	0.55	0.55	0.65	0.75	0.8	0.85	0.9
0.3	0	0.1	0.35	0.4	0.3	0.15	0.25	0.35	0.17	0.22	0.3	0.17	0.35	0.25
0.6	0.1	0.3	0.6	0.7	0.6	0.4	0.55	0.65	0.4	0.45	0.6	0.4	0.65	0.55
0.35	0.2	0	0.32	0.5	0.37	0.15	0.25	0.1	0.6	0.02	0.15	0.55	0.45	0.15
0.6	0.4	0.1	0.55	0.8	0.65	0.3	0.55	0.25	0.9	0.15	0.3	0.85	0.75	0.3
0.6	0.4	0.05	0	0.6	0.67	0.37	0.37	0.5	0.4	0.3	0.75	0.3	0.6	0.67
0.9	0.7	0.2	0.1	0.9	0.77	0.65	0.8	0.8	0.7	0.6	0.95	0.6	0.9	0.92
0.3	0.35	0	0.25	0	0.6	0.4	0.65	0.5	0.4	0.25	0.5	0.2	0.55	0.2
0.6	0.6	0.1	0.5	0.1	0.9	0.7	0.85	0.8	0.7	0.5	0.8	0.5	0.85	0.5
0.5	0.25	0.3	0.5	0.6	0	0.5	0.65	0.5	0.3	0.4	0.6	0.4	0.72	0.52
0.8	0.5	0.5	0.65	0.9	0.1	0.8	0.85	0.8	0.6	0.7	0.9	0.7	0.87	0.77
0.65	0.25	0.2	0.5	0.3	0.6	0	0.65	0.6	0.5	0.75	0.5	0.4	0.5	0.52
0.85	0.5	0.4	0.65	0.6	0.9	0.1	0.85	0.9	0.8	0.95	0.8	0.7	0.8	0.77
0.6	0.12	0.05	0.12	0.35	0.4	0.15	0	0.27	0.2	0.12	0.2	0.1	0.55	0.2
0.9	0.35	0.2	0.35	0.65	0.7	0.4	0.1	0.55	0.45	0.35	0.5	0.3	0.85	0.5
0.52	0.1	0.25	0.4	0.3	0.4	0.4	0.55	0	0.15	0.17	0.4	0.2	0.2	0.6
0.77	0.3	0.5	0.7	0.6	0.7	0.7	0.75	0.1	0.4	0.45	0.7	0.5	0.5	0.9
0.6	0.1	0.1	0.2	0.6	0.75	0.35	0.5	0.75	0	0.17	0.6	0.72	0.45	0.6
0.9	0.25	0.3	0.4	0.9	0.95	0.6	0.8	0.95	0.1	0.4	0.9	0.87	0.75	0.9
0.3	0.1	0	0.45	0.4	0.55	0.75	0.5	0.4	0.25	0	0.45	0.25	0.45	0.45
0.6	0.3	0.1	0.55	0.7	0.75	0.95	0.8	0.7	0.5	0.1	0.75	0.55	0.75	0.75
0.3	0.55	0.05	0.5	0.4	0.6	0.6	0.4	0.45	0.35	0.65	0	0.5	0.5	0.6
0.6	0.75	0.2	0.8	0.7	0.9	0.9	0.7	0.75	0.65	0.85	0.1	0.8	0.8	0.9
0.3	0.4	0.3	0.3	0.4	0.75	0.4	0.42	0.7	0.67	0.25	0.6	0	0.6	0.4
0.6	0.65	0.5	0.5	0.7	0.95	0.7	0.7	0.9	0.92	0.55	0.9	0.1	0.9	0.7
0.35	0.27	0	0.25	0.9	0.3	0.4	0.55	0.47	0.4	0.3	0.4	0.65	0	0.5
0.65	0.55	0.1	0.5	1	0.6	0.7	0.85	0.72	0.7	0.6	0.7	0.85	0.1	0.8
0.4	0.5	0.3	0.35	0.55	0.37	0.9	0.3	0.45	0.55	0.75	0.95	0.5	0.4	0
0.7	0.8	0.5	0.6	0.85	0.62	1	0.6	0.75	0.75	0.95	0.95	0.65	0.7	0.1

CSF	SC	IN	SO	SI	IM	SRV
SC	0	0.25	0.35	0.45	0.17	0.45
	0.1	0.5	0.6	0.75	0.45	0.75
	0.2	0	0.3	0.1	0.25	0.12
IN	0.5	0.1	0.55	0.3	0.5	0.35
	0	0.6	0	0.12	0.22	0.07
SO	0.1	0.9	0.1	0.35	0.45	0.25
	0.6	0.15	0.27	0	0.45	0.5
SI	0.8	0.35	0.55	0.1	0.75	0.8
	0.5	0.45	0.45	0.82	0	0.3
IM	0.8	0.75	0.75	0.97	0.1	0.6
	0.45	0.45	0.35	0.75	0.52	0
SRV	0.7	0.55	0.65	0.95	0.7	0.1
BD	0.17	0.9	0.67	0.22	0.37	0.22
	0.4	1	0.92	0.45	0.62	0.45
MP	0.1	0.4	0.82	0.12	0.4	0.4
	0.3	0.7	0.97	0.35	0.7	0.7
V	0.15	0.25	0.25	0.02	0.2	0.3
RM	0.3	0.55	0.55	0.15	0.4	0.5
	0.15	0.3	0.4	0.1	0.25	0.35
QD	0.4	0.6	0.7	0.3	0.55	0.65
	0.05	0.4	0.25	0.15	0.32	0.2
OA	0.2	0.7	0.5	0.4	0.6	0.5
	0.3	0.6	0.4	0.35	0.47	0.47
SD	0.6	0.9	0.7	0.6	0.75	0.75
	0.35	0.4	0.4	0.4	0.77	0.17
EL	0.6	0.7	0.7	0.7	0.92	0.45
	0.5	0.9	0.2	0.15	0.25	0.25
EIC	0.8	1	0.5	0.4	0.5	0.5
	0.35	0.37	0.15	0.57	0.35	0.15
ISP	0.65	0.57	0.4	0.82	0.6	0.4
	0.25	0.2	0.22	0.25	0.2	0.17
INV	0.55	0.45	0.5	0.55	0.45	0.4
	0.1	0.17	0.25	0.17	0.27	0.42
AT	0.3	0.45	0.5	0.45	0.55	0.7
	0.52	0.32	0.45	0.65	0.62	0.4
SO	0.77	0.6	0.75	0.85	0.87	0.7
	0.3	0.3	0.25	0.4	0.5	0.35
EFT	0.6	0.6	0.55	0.7	0.65	0.6
	0.25	0.6	0.52	0.3	0.5	0.47
SD	0.55	0.9	0.77	0.6	0.8	0.6
	0.12	0.4	0.35	0.3	0.6	0.45
CI	0.35	0.7	0.65	0.6	0.9	0.75

Step 4- The crisp relation matrix is computed using a three-step- modified converting fuzzy values into crisp scores approach. By using equations 3, 4, and 5 the grey value normalization is performed then total normalized crisp values are obtained using equation 6, and in the final step, the grey values are transformed into crisp values using equations 7 and 8 as shown in table 13.

Table 13: Crisp relation matrix of BT-enabled CSFs for SCRS

EIC	ISP	INV	AT	SO	EFT	SDM	CI
0.2750	0.5868	0.5263	0.2842	0.4053	0.5263	0.4658	0.4658
0.7800	0.1555	0.1200	0.1200	0.3071	0.1929	0.4500	0.2320
0.5091	0.4645	0.2320	0.1200	0.1929	0.3071	0.6786	0.5091
0.1919	0.7901	0.3300	0.2711	0.5067	0.2711	0.5067	0.3889
0.3833	0.6750	0.3250	0.7333	0.8273	0.3833	0.6167	0.7727
0.3870	0.4028	0.3870	0.1190	0.3283	0.1190	0.5630	0.5630
0.8143	0.3250	0.3250	0.4417	0.5718	0.6167	0.6750	0.7333
0.3266	0.4436	0.2091	0.2648	0.3851	0.2091	0.4436	0.3266
0.3318	0.1079	0.7455	0.0264	0.1605	0.6864	0.5682	0.1605
0.6217	0.6217	0.5043	0.3870	0.8310	0.3870	0.7391	0.7875
0.7250	0.6273	0.5091	0.3071	0.6273	0.2727	0.6864	0.2727
0.7250	0.6273	0.3909	0.5091	0.7455	0.5091	0.7658	0.6214
0.7214	0.7391	0.6217	0.8310	0.6217	0.5043	0.6217	0.6170
0.0000	0.3420	0.2457	0.1528	0.2667	0.1182	0.6750	0.2667
0.5905	0.0000	0.1815	0.2192	0.4863	0.2586	0.2586	0.7193
0.6090	0.8200	0.0000	0.2033	0.7259	0.7533	0.5508	0.7259
0.6090	0.4928	0.2959	0.0000	0.5508	0.3198	0.5508	0.5508
0.4863	0.5441	0.4289	0.7012	0.0000	0.6022	0.6022	0.7193
0.5065	0.7645	0.7750	0.3198	0.7259	0.0000	0.7259	0.4928
0.6750	0.5565	0.5000	0.3833	0.5000	0.7182	0.0000	0.6167
0.3833	0.5583	0.6091	0.8273	0.8273	0.5262	0.5000	0.0000

CSFs	SC	IN	SOG	SI	IM	SRV	BDO	MPV	RMS	QDF	OA	SD	EL
SC	0.0000	0.3167	0.4333	0.5868	0.2412	0.5868	0.3893	0.1607	0.1625	0.5263	0.4053	0.5868	0.5792
IN	0.2727	0.0000	0.3643	0.1200	0.3071	0.1555	0.7800	0.0865	0.3071	0.1929	0.2727	0.2727	0.0865
SOG	0.0000	0.7455	0.0000	0.1555	0.2677	0.0865	0.3483	0.0865	0.1079	0.1555	0.7455	0.5682	0.1750
SI	0.6683	0.1744	0.3466	0.0000	0.5656	0.6244	0.2667	0.1548	0.0551	0.6833	0.2711	0.2711	0.6244
IM	0.6167	0.5583	0.5583	0.8667	0.0000	0.3833	0.7182	0.4569	0.0262	0.7826	0.3833	0.6130	0.9000
SRV	0.5318	0.4500	0.4457	0.8310	0.5689	0.0000	0.3773	0.4028	0.0263	0.4028	0.2696	0.4457	0.2696
BDO	0.2083	0.9000	0.7826	0.2639	0.4435	0.2639	0.0000	0.3022	0.2846	0.4435	0.6750	0.6167	0.3833
MPV	0.1186	0.5021	0.8677	0.1534	0.5021	0.5021	0.3851	0.0000	0.1186	0.4167	0.5021	0.3851	0.1900
RMS	0.1605	0.3318	0.3318	0.0264	0.2300	0.3400	0.4214	0.2300	0.0000	0.3799	0.6273	0.4645	0.1605
QDF	0.1909	0.3870	0.5043	0.1190	0.3283	0.4457	0.7391	0.5043	0.0550	0.0000	0.7391	0.6750	0.4606
OA	0.0553	0.5091	0.3071	0.1929	0.4064	0.2727	0.3909	0.4214	0.0000	0.3071	0.0000	0.7455	0.5091
SD	0.3909	0.7455	0.5091	0.4214	0.5808	0.5808	0.6273	0.3071	0.3400	0.5289	0.7455	0.0000	0.6273
EL	0.4182	0.5043	0.5043	0.5043	0.8163	0.2294	0.7214	0.3045	0.2286	0.5275	0.3870	0.7391	0.0000
EIC	0.6167	0.9000	0.2667	0.1891	0.3022	0.3022	0.7333	0.1528	0.0548	0.1528	0.4417	0.5000	0.1891
ISP	0.4289	0.4005	0.1815	0.6533	0.4003	0.1815	0.5965	0.1118	0.2901	0.4863	0.3718	0.4863	0.4863
INV	0.3198	0.2405	0.2793	0.3198	0.2405	0.2033	0.7259	0.1032	0.1149	0.2211	0.7259	0.8200	0.4074
AT	0.1149	0.2230	0.2959	0.2230	0.3358	0.5065	0.3773	0.1149	0.0000	0.4379	0.4928	0.5994	0.8200
SO	0.5965	0.3862	0.5441	0.7012	0.7105	0.4863	0.3718	0.5905	0.0508	0.6022	0.4863	0.7193	0.7193
EFT	0.3773	0.3773	0.3198	0.4928	0.5152	0.4074	0.3773	0.4635	0.3282	0.3282	0.4928	0.8200	0.4928
SDM	0.3250	0.7333	0.6130	0.3833	0.6167	0.4872	0.4417	0.3420	0.0000	0.3022	0.9000	0.3833	0.5000
CI	0.1528	0.5000	0.4417	0.3833	0.7333	0.5583	0.5000	0.6167	0.3364	0.4152	0.6750	0.4435	0.9000

Step 5- Normalization of crisp relation matrix is performed using equations 9 and 10. The normalized direct crisp relation matrix A is presented in Table 14.

Table 14: Normalised direct crisp relation matrix of BT-enabled CSFs for SCRS

CI
0.0400
0.0199
0.0437
0.0334
0.0664
0.0484
0.0630
0.0280
0.0138
0.0676
0.0234
0.0534
0.0530
0.0229
0.0618
0.0623
0.0473
0.0618
0.0423
0.0530
0.0000

SI	IM	SRV	BDO	MPV	RMS	QDF	OA	SD	EL	EIC	ISP	INV	AT	SO	EFT	SDM
0.0504	0.0207	0.0504	0.0334	0.0138	0.0140	0.0452	0.0348	0.0504	0.0497	0.0236	0.0504	0.0452	0.0244	0.0348	0.0452	0.0400
0.0103	0.0264	0.0134	0.0670	0.0074	0.0264	0.0166	0.0234	0.0234	0.0074	0.0670	0.0134	0.0103	0.0103	0.0264	0.0166	0.0386
0.0134	0.0230	0.0074	0.0299	0.0074	0.0093	0.0134	0.0640	0.0488	0.0150	0.0437	0.0399	0.0199	0.0103	0.0166	0.0264	0.0583
0.0000	0.0486	0.0536	0.0229	0.0133	0.0047	0.0587	0.0233	0.0233	0.0536	0.0165	0.0679	0.0283	0.0233	0.0435	0.0233	0.0435
0.0744	0.0000	0.0329	0.0617	0.0392	0.0023	0.0672	0.0329	0.0526	0.0773	0.0329	0.0580	0.0279	0.0630	0.0710	0.0329	0.0530
0.0714	0.0489	0.0000	0.0324	0.0346	0.0023	0.0346	0.0232	0.0383	0.0232	0.0332	0.0346	0.0332	0.0102	0.0282	0.0102	0.0484
0.0227	0.0381	0.0227	0.0000	0.0260	0.0244	0.0381	0.0580	0.0530	0.0329	0.0699	0.0279	0.0279	0.0379	0.0491	0.0530	0.0580
0.0132	0.0431	0.0431	0.0331	0.0000	0.0102	0.0358	0.0431	0.0331	0.0163	0.0280	0.0381	0.0180	0.0227	0.0331	0.0180	0.0381
0.0023	0.0198	0.0292	0.0362	0.0198	0.0000	0.0326	0.0539	0.0399	0.0138	0.0285	0.0093	0.0640	0.0023	0.0138	0.0589	0.0488
0.0102	0.0282	0.0383	0.0635	0.0433	0.0047	0.0000	0.0635	0.0580	0.0396	0.0534	0.0534	0.0433	0.0332	0.0714	0.0332	0.0635
0.0166	0.0349	0.0234	0.0336	0.0362	0.0000	0.0264	0.0000	0.0640	0.0437	0.0623	0.0539	0.0437	0.0264	0.0539	0.0234	0.0589
0.0362	0.0499	0.0499	0.0539	0.0264	0.0292	0.0454	0.0640	0.0000	0.0539	0.0623	0.0539	0.0336	0.0437	0.0640	0.0437	0.0658
0.0433	0.0701	0.0197	0.0620	0.0262	0.0196	0.0453	0.0332	0.0635	0.0000	0.0620	0.0635	0.0534	0.0714	0.0534	0.0433	0.0534
0.0162	0.0260	0.0260	0.0630	0.0131	0.0047	0.0131	0.0379	0.0429	0.0162	0.0000	0.0294	0.0211	0.0131	0.0229	0.0101	0.0580
0.0561	0.0344	0.0156	0.0512	0.0096	0.0249	0.0418	0.0319	0.0418	0.0418	0.0507	0.0000	0.0156	0.0188	0.0418	0.0222	0.0222
0.0275	0.0207	0.0175	0.0623	0.0089	0.0099	0.0190	0.0623	0.0704	0.0350	0.0523	0.0704	0.0000	0.0175	0.0623	0.0647	0.0473
0.0191	0.0288	0.0435	0.0324	0.0099	0.0000	0.0376	0.0423	0.0515	0.0704	0.0523	0.0423	0.0254	0.0000	0.0473	0.0275	0.0473
0.0602	0.0610	0.0418	0.0319	0.0507	0.0044	0.0517	0.0418	0.0618	0.0618	0.0418	0.0467	0.0368	0.0602	0.0000	0.0517	0.0517
0.0423	0.0442	0.0350	0.0324	0.0398	0.0282	0.0282	0.0423	0.0704	0.0423	0.0435	0.0657	0.0666	0.0275	0.0623	0.0000	0.0623
0.0329	0.0530	0.0418	0.0379	0.0294	0.0000	0.0260	0.0773	0.0329	0.0429	0.0580	0.0478	0.0429	0.0329	0.0429	0.0617	0.0000
0.0329	0.0630	0.0480	0.0429	0.0530	0.0289	0.0357	0.0580	0.0381	0.0773	0.0329	0.0480	0.0523	0.0710	0.0710	0.0452	0.0429

CSFs	SC	IN	SOG	SI	IM	SRV	BDO	MPV	RMS	QDF	OA	SD	EL	EIC	ISP	INV	AT	SO	EFT	SDM	CI	
SC	0.0000	0.0272	0.0372																			
IN	0.0234	0.0000	0.0313																			
SOG	0.0000	0.0640	0.0000																			
SI	0.0574	0.0150	0.0298	0.0000																		
IM	0.0530	0.0480	0.0480	0.0298	0.0000																	
SRV	0.0457	0.0386	0.0383	0.0480	0.0480	0.0000																
BDO	0.0179	0.0773	0.0672	0.0150	0.0480	0.0386	0.0000															
MPV	0.0102	0.0431	0.0745	0.0150	0.0480	0.0386	0.0773	0.0000														
RMS	0.0138	0.0285	0.0285	0.0150	0.0480	0.0386	0.0773	0.0431	0.0000													
QDF	0.0164	0.0332	0.0433	0.0150	0.0480	0.0386	0.0773	0.0431	0.0285	0.0000												
OA	0.0047	0.0437	0.0264	0.0150	0.0480	0.0386	0.0773	0.0431	0.0285	0.0164	0.0000											
SD	0.0336	0.0640	0.0437	0.0150	0.0480	0.0386	0.0773	0.0431	0.0285	0.0047	0.0332	0.0000										
EL	0.0359	0.0433	0.0433	0.0150	0.0480	0.0386	0.0773	0.0431	0.0285	0.0047	0.0332	0.0640	0.0000									
EIC	0.0530	0.0773	0.0229	0.0150	0.0480	0.0386	0.0773	0.0431	0.0285	0.0047	0.0332	0.0640	0.0437	0.0000								
ISP	0.0368	0.0344	0.0156	0.0150	0.0480	0.0386	0.0773	0.0431	0.0285	0.0047	0.0332	0.0640	0.0437	0.0332	0.0000							
INV	0.0275	0.0207	0.0240	0.0150	0.0480	0.0386	0.0773	0.0431	0.0285	0.0047	0.0332	0.0640	0.0437	0.0332	0.0344	0.0000						
AT	0.0099	0.0191	0.0254	0.0150	0.0480	0.0386	0.0773	0.0431	0.0285	0.0047	0.0332	0.0640	0.0437	0.0332	0.0344	0.0207	0.0000					
SO	0.0512	0.0332	0.0467	0.0150	0.0480	0.0386	0.0773	0.0431	0.0285	0.0047	0.0332	0.0640	0.0437	0.0332	0.0344	0.0207	0.0191	0.0000				
EFT	0.0324	0.0324	0.0275	0.0150	0.0480	0.0386	0.0773	0.0431	0.0285	0.0047	0.0332	0.0640	0.0437	0.0332	0.0344	0.0207	0.0191	0.0254	0.0000			
SDM	0.0279	0.0630	0.0526	0.0150	0.0480	0.0386	0.0773	0.0431	0.0285	0.0047	0.0332	0.0640	0.0437	0.0332	0.0344	0.0207	0.0191	0.0254	0.0324	0.0000		
CI	0.0131	0.0429	0.0379	0.0150	0.0480	0.0386	0.0773	0.0431	0.0285	0.0047	0.0332	0.0640	0.0437	0.0332	0.0344	0.0207	0.0191	0.0254	0.0324	0.0630	0.0000	

Step 6- The total relation matrix of BT-enabled CSFs for SCRS T_R is calculated using equation 11 and shown in Table 15.

Step 7- Let R and C be vectors with dimensions of 21 by 1 and 1 by 21, respectively, reflecting the sum of row elements and column elements in the total relation matrix T_R , as described by Equations 12 and 13.

Step 8- A threshold value is established by adding 1 time the standard deviation to the mean of the items in the total relation matrix T_R to eliminate minor causes/effects among enablers before plotting a causal relation between them. The direct and indirect impacts that BT-enabled CSFs m have on other BT-enabled CSFs are summarised in R_m , and the direct and indirect effects that BT-enabled CSFs have on other BT-enabled CSFs are summarised in C_n . $(R_m + C_n)$ and $(R_m - C_n)$ is calculated from the total relation matrix T_R and presented in Table 15. Figure 9 represents the obtained digraph. It displays the causal relation among BT-enabled CSFs for SCRS from the values of $(R_m + C_n)$ and $(R_m - C_n)$. The direction from causes BT-enabled CSFs to affect BT-enabled CSFs is represented through lines and represents the two-way relationships among CSFs.

Table 15: Total relation matrix of BT-enabled CSFs for SCRS

SO	EFT	SDM	CI
<u>0.1810</u>	<u>0.1556</u>	<u>0.1952</u>	<u>0.1851</u>
<u>0.1182</u>	<u>0.0890</u>	<u>0.1392</u>	<u>0.1125</u>
<u>0.1257</u>	<u>0.1087</u>	<u>0.1725</u>	<u>0.1487</u>
<u>0.1820</u>	<u>0.1292</u>	<u>0.1895</u>	<u>0.1735</u>
<u>0.2666</u>	<u>0.1834</u>	<u>0.2620</u>	<u>0.2616</u>
<u>0.1622</u>	<u>0.1129</u>	<u>0.1894</u>	<u>0.1802</u>
<u>0.2138</u>	<u>0.1781</u>	<u>0.2358</u>	<u>0.2245</u>
<u>0.1520</u>	<u>0.1089</u>	<u>0.1669</u>	<u>0.1479</u>
<u>0.1259</u>	<u>0.1431</u>	<u>0.1673</u>	<u>0.1241</u>
<u>0.2404</u>	<u>0.1643</u>	<u>0.2447</u>	<u>0.2360</u>
<u>0.1914</u>	<u>0.1297</u>	<u>0.2059</u>	<u>0.1630</u>
<u>0.2497</u>	<u>0.1865</u>	<u>0.2653</u>	<u>0.2389</u>
<u>0.2425</u>	<u>0.1876</u>	<u>0.2546</u>	<u>0.2412</u>
<u>0.1366</u>	<u>0.0990</u>	<u>0.1783</u>	<u>0.1365</u>
<u>0.1759</u>	<u>0.1253</u>	<u>0.1666</u>	<u>0.1925</u>
<u>0.2200</u>	<u>0.1844</u>	<u>0.2158</u>	<u>0.2180</u>
<u>0.1857</u>	<u>0.1329</u>	<u>0.1948</u>	<u>0.1849</u>
<u>0.1907</u>	<u>0.1930</u>	<u>0.2514</u>	<u>0.2473</u>
<u>0.2328</u>	<u>0.1336</u>	<u>0.2437</u>	<u>0.2134</u>
<u>0.2090</u>	<u>0.1848</u>	<u>0.1796</u>	<u>0.2161</u>
<u>0.2533</u>	<u>0.1850</u>	<u>0.2397</u>	<u>0.1852</u>

SC	IN	SOG	SI	IM	SRV	BDO	MPV	RMS	QDF	OA	SD	EL	EIC	ISP	INV	AT
0.0929	<u>0.1645</u>	0.1556	0.1559	0.1484	0.1508	<u>0.1734</u>	0.0969	0.0554	0.1558	<u>0.1774</u>	<u>0.1987</u>	<u>0.1797</u>	<u>0.1718</u>	<u>0.1951</u>	0.1537	0.1281
0.0823	0.0937	0.1089	0.0772	0.1063	0.0785	0.1553	0.0607	0.0523	0.0872	0.1169	0.1194	0.0908	0.1605	0.1045	0.0805	0.0764
0.0684	<u>0.1676</u>	0.0891	0.0906	0.1172	0.0827	0.1358	0.0694	0.0409	0.0948	<u>0.1691</u>	0.1576	0.1122	0.1556	0.1453	0.1004	0.0876
0.1441	0.1454	0.1433	0.1051	<u>0.1680</u>	0.1490	0.1570	0.0929	0.0436	<u>0.1646</u>	0.1585	<u>0.1662</u>	<u>0.1784</u>	0.1566	<u>0.2042</u>	0.1320	0.1234
<u>0.1757</u>	<u>0.2329</u>	<u>0.2101</u>	<u>0.2154</u>	<u>0.1741</u>	<u>0.1718</u>	<u>0.2493</u>	0.1506	0.0586	<u>0.2176</u>	<u>0.2260</u>	<u>0.2531</u>	<u>0.2541</u>	<u>0.2330</u>	<u>0.2531</u>	<u>0.1749</u>	<u>0.2042</u>
0.1300	<u>0.1648</u>	0.1485	<u>0.1668</u>	<u>0.1639</u>	0.0953	<u>0.1610</u>	0.1094	0.0401	0.1377	0.1544	<u>0.1729</u>	0.1447	<u>0.1669</u>	<u>0.1679</u>	0.1314	0.1066
0.1219	<u>0.2352</u>	<u>0.2016</u>	0.1414	<u>0.1820</u>	0.1384	<u>0.1629</u>	0.1206	0.0715	<u>0.1626</u>	<u>0.2211</u>	<u>0.2222</u>	<u>0.1814</u>	<u>0.2382</u>	<u>0.1921</u>	0.1523	0.1554
0.0852	0.1588	<u>0.1714</u>	0.1008	0.1460	0.1246	0.1491	0.0687	0.0438	0.1262	<u>0.1612</u>	0.1559	0.1238	0.1513	0.1556	0.1066	0.1074
0.0823	0.1347	0.1192	0.0820	0.1148	0.1048	0.1429	0.0828	0.0315	0.1141	<u>0.1632</u>	0.1543	0.1115	0.1425	0.1206	0.1460	0.0798
0.1236	<u>0.1984</u>	<u>0.1845</u>	0.1355	<u>0.1784</u>	0.1567	<u>0.2265</u>	0.1408	0.0537	0.1307	<u>0.2311</u>	<u>0.2323</u>	<u>0.1934</u>	<u>0.2275</u>	<u>0.2213</u>	<u>0.1697</u>	0.1564
0.0948	<u>0.1773</u>	0.1414	0.1185	0.1560	0.1200	<u>0.1695</u>	0.1140	0.0400	0.1322	0.1381	<u>0.2042</u>	<u>0.1673</u>	<u>0.2033</u>	<u>0.1901</u>	0.1447	0.1260
0.1521	<u>0.2419</u>	<u>0.1980</u>	<u>0.1727</u>	<u>0.2126</u>	<u>0.1796</u>	<u>0.2348</u>	0.1337	0.0814	<u>0.1882</u>	<u>0.2466</u>	<u>0.1945</u>	<u>0.2216</u>	<u>0.2525</u>	<u>0.2384</u>	<u>0.1742</u>	<u>0.1771</u>
0.1550	<u>0.2228</u>	<u>0.1979</u>	<u>0.1801</u>	<u>0.2311</u>	0.1528	<u>0.2434</u>	0.1328	0.0729	<u>0.1898</u>	<u>0.2197</u>	<u>0.2557</u>	<u>0.1736</u>	<u>0.2526</u>	<u>0.2494</u>	<u>0.1922</u>	<u>0.2045</u>
0.1230	<u>0.1855</u>	0.1186	0.0994	0.1246	0.1053	<u>0.1722</u>	0.0773	0.0383	0.1006	0.1500	0.1581	0.1184	0.1194	0.1409	0.1054	0.0941
0.1217	<u>0.1616</u>	0.1268	0.1515	0.1512	0.1110	<u>0.1797</u>	0.0871	0.0629	0.1448	<u>0.1629</u>	<u>0.1780</u>	<u>0.1631</u>	<u>0.1848</u>	0.1338	0.1172	0.1166
0.1275	<u>0.1732</u>	0.1537	0.1435	0.1601	0.1286	<u>0.2125</u>	0.1007	0.0564	0.1406	<u>0.2163</u>	<u>0.2311</u>	<u>0.1788</u>	<u>0.2128</u>	<u>0.2255</u>	0.1200	0.1324
0.0989	0.1527	0.1393	0.1216	0.1512	0.1388	<u>0.1668</u>	0.0902	0.0396	0.1429	<u>0.1774</u>	<u>0.1927</u>	<u>0.1934</u>	<u>0.1926</u>	<u>0.1797</u>	0.1292	0.1019
<u>0.1683</u>	<u>0.2106</u>	<u>0.2007</u>	<u>0.1960</u>	<u>0.2232</u>	<u>0.1738</u>	<u>0.2130</u>	0.1561	0.0577	<u>0.1956</u>	<u>0.2251</u>	<u>0.2523</u>	<u>0.2313</u>	<u>0.2307</u>	<u>0.2344</u>	<u>0.1768</u>	<u>0.1939</u>
0.1416	<u>0.1953</u>	<u>0.1690</u>	<u>0.1678</u>	<u>0.1933</u>	0.1551	<u>0.1987</u>	0.1364	0.0762	0.1605	<u>0.2111</u>	<u>0.2442</u>	<u>0.1971</u>	<u>0.2172</u>	<u>0.2350</u>	<u>0.1926</u>	0.1503
0.1326	<u>0.2198</u>	<u>0.1872</u>	0.1540	<u>0.1959</u>	0.1559	<u>0.1988</u>	0.1237	0.0478	0.1525	<u>0.2363</u>	<u>0.2045</u>	<u>0.1917</u>	<u>0.2260</u>	<u>0.2124</u>	<u>0.1658</u>	0.1510
0.1299	<u>0.2160</u>	<u>0.1897</u>	<u>0.1675</u>	<u>0.2220</u>	<u>0.1749</u>	<u>0.2202</u>	0.1564	0.0794	<u>0.1774</u>	<u>0.2363</u>	<u>0.2283</u>	<u>0.2410</u>	<u>0.2207</u>	<u>0.2305</u>	<u>0.1885</u>	<u>0.2014</u>

CSFs	SC	IN	SOG	SI	IM	SRV	BDO	MPV	RMS	QDF	OA	SD	EL	EIC	ISP	INV	AT	SO	EFT	SDM	CI
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5.3 Results & Discussions

The relationships and direct effects of twenty-one BT-enabled CSFs are explored in this work utilizing a combination of grey theory and DEMATEL methodologies. The importance and net cause/effect values of BT-enabled CSFs for SCRS are shown in Table 16. A threshold value (T_v) of 0.16102 is chosen to filter out relatively insignificant effects. The threshold value is obtained by adding one standard deviation to the mean and calculating the mean and standard deviation of the values from the total relation matrix (Xia et al., 2015). In the total relation matrix T_R , all relationships that reach or exceed the threshold value are highlighted (Table 15).

Table 16: Cause and effect parameters for BT-enabled CSFs SCRS

BT enabled CSFs	R_m	C_n	$R_m - C_n$	$R_m + C_n$	Cause/Effect
SC	2.551965	3.270991	-0.71903	5.822957	Effect
IN	3.852768	2.110321	1.742448	5.963089	Cause
SOG	3.354615	2.440209	0.914406	5.794824	Cause
SI	2.943178	3.106378	-0.1632	6.049556	Effect
IM	3.520301	4.428158	-0.90786	7.948458	Effect
SRV	2.848451	3.007125	-0.15867	5.855576	Effect
BDO	3.922768	3.752972	0.169795	7.67574	Cause
MPV	2.301375	2.711791	-0.41042	5.013166	Effect
RMS	1.143968	2.487533	-1.34357	3.631501	Effect
QDF	3.116329	3.845944	-0.72961	6.962274	Effect
OA	3.998673	3.1273	0.871374	7.125973	Cause
SD	4.176166	4.240575	-0.06441	8.416741	Effect
EL	3.647166	4.252252	-0.60509	7.899419	Effect
EIC	4.116416	2.581579	1.534838	6.697995	Cause
ISP	4.029777	3.014887	1.01489	7.044664	Cause
INV	3.054002	3.551849	-0.49785	6.605851	Effect
AT	2.874564	3.107235	-0.23267	5.981799	Effect
SO	4.055433	4.221876	-0.16644	8.277309	Effect
EFT	3.115188	3.864746	-0.74956	6.979935	Effect

SDM	4.35818	3.74556	0.61262	8.10374	Cause
CI	4.031287	4.14329	-0.112	8.174577	Effect

Figure 9 shows the digraph showing causal relations among BT-enabled CSFs for SCRS. When multiple related factors interact, the decision-making environment can quickly become complicated. Therefore, it is essential to discover the dependent relationship in order to identify the elements in causal groups that can be enhanced in order to enhance the components in the effect group and, by extension, the entire system (Gupta & Barua, 2018). The results are further reviewed in this section from the perspectives of the cause group, the effect group, and the correlation among BT-enabled CSFs, followed by a sensitivity analysis.

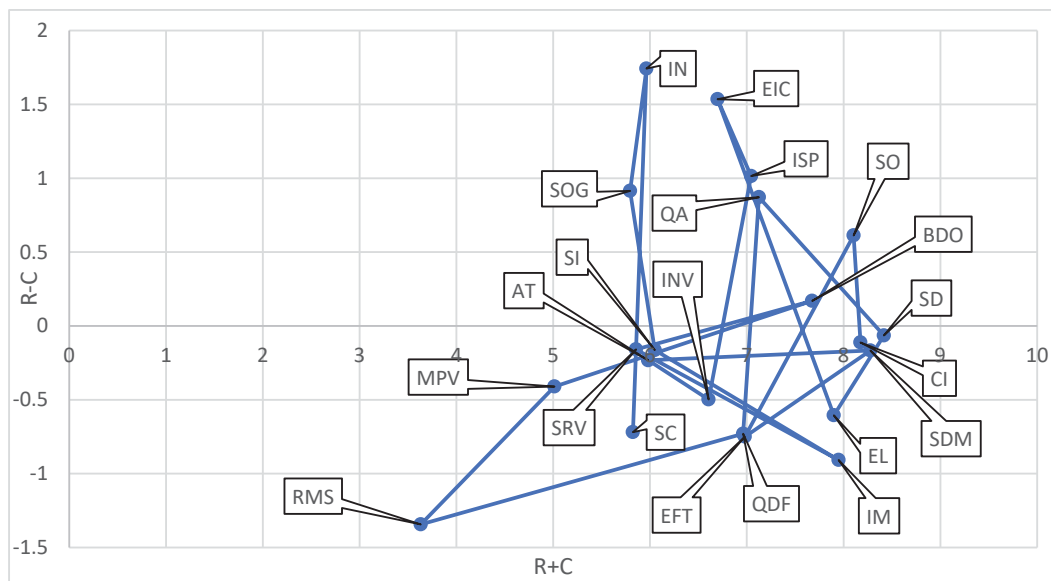


Figure 9: Digraph showing causal relations among BT-enabled CSFs for SCRS

5.3.1 Cause group

The causal or driver BT-enabled CSFs are ranked based on their $(R_m - C_n) \forall m - n$ values as $IN > EIC > ISP > SOG > OA > SDM > BDO$ (table 9). Internal integration (IN) is found to be the crucial driving BT-enabled CSFs, as it initiates the effects of many other BT-enabled CSFs. BT-enabled internal integration uses combined serial numbers, bar codes, sensors, digital tags, etc., and creates a unified and transparent platform that uses a distributed database to make other processes more resilient and sustainable. Being on top of the causal list internal integrations affects the SD the most followed by IM, EL, CI, SO, QDF, EFT, INV, SRV, AND SC respectively. It has a significant effect on most of the CSFs and thus, proved critical to the success of SCRS.

Internal integration is followed by efficient inter-organization communication (EIC) and Integration of Strategic Partners (ISP). Efficient inter-organization communication (EIC) facilitates more streamlined and automated communication between the entities while maintaining the highest possible level of trust thus, increasing the resilience among other stakeholders. EIC has prominent effects on EL, SD, IM, SO, QDF, CI, EFT, INV, AT, and SC respectively in decreasing order. Whereas Integration of Strategic Partners (ISP) helps smoothen the information flow regarding ongoing processes from the beginning to the end, giving the required supply chain entities on blockchain access to data free from bias and error. It has prominent effects on IM followed by EL, SD, EFT, SO, CI, INV, QDF, SI, SC, and AT respectively. The findings are acknowledged by industrial managers as they consider these CSFs as a significant factor of SCRS.

5.3.2 Effect Group

The effect CSFs can be sorted as SD, CI, SRV, SI, SO, AT, MPV, INV, EL, SC, QDF, EFT, IM, and RMS in decreasing order of their prominence. Standardized Data Management (SD) is closer to the cause group and thus less influenced by them. SD has followed customer integration (CI), which facilitates the integration of customers among SCs by keeping track of each purchase order and providing a copy of the information available to stockholders due to its distributed nature. It increases transparency and traceability along with other features of SCRS. Supplier and Raw material Verification (SRV) hold the third position in the effect group. BT-enabled SRV process reduces the possibility of data manipulation and forgeries by logging each transaction and flow of data after supply chain confirmation and forbidding any kind of modification. Thus, increasing the trust among stakeholders and enhancing product quality.

5.3.3 Correlation among BT-enabled CSFs

To understand the correlation among BT-enabled CSFs the BT can be prioritized based on $(R_m + C_n) \forall m - n$ values. The correlation order of this investigation is SD > SO > CI > SDM > IM > EL > BDO > OA > ISP > EFT > QDF > EIC > INV > SI > AT > IN > SRV > SC > SOG > MPV > RMS. As per this ranking, Standardized Data Management (SD) has the highest correlation with the other CSFs and is the most important BT-enabled CSF for SCRS. BT-enabled standardized data management creates an immutable audit log to capture the data transaction after verification in supply chains and eliminate the possibility of data being manipulated or falsified. It also forbids modification or tampering with the data, thus increasing

the assurance and trust among all the stakeholders and eventually making the processes efficient and resilient. Thus, proved critical to the success of SCRS. Smart ordering (SO) is the second most correlated BT-enabled CSF as it can help participants manage the orders more effectively by providing them with the track of data like pricing, dates, location, quality, certifications, and other important factors. Customer integration (CI) is the third most correlated CSF as it keeps track of each purchase order and makes a copy of the information accessible to stockholders for efficient processing it also proved critical during uncertain circumstances thus, increasing the resilience and sustainability of the supply chain. Standardized Document Management (SDM) holds the fourth rank in correlation among CSFs, the usage of standard tools, methods, and performance measure indicators helps to keep the standard documents in good functioning order, which reduces error and facilitates creating a resilient and sustainable process.

Further analysis is performed by categorizing all the BT-enabled CSFs into different zones, Due to their dependence on causal CSFs, CSFs below the x-axis are referred to as effect CSFs and are also known as dysfunctional group CSFs. CSFs above the x-axis have the greatest prominence and are known as causal CSFs. According to Figure 10, the entire collection of CSFs can be split into four distinct groups, with zone 1 consisting of CSFs with the fewest connections, or CSFs with the least significance. The revenue management system for employees (RMS) belongs to this group of lowest significance whereas, Manufacturing Parameter Validation (MPV) lies on the boundary.

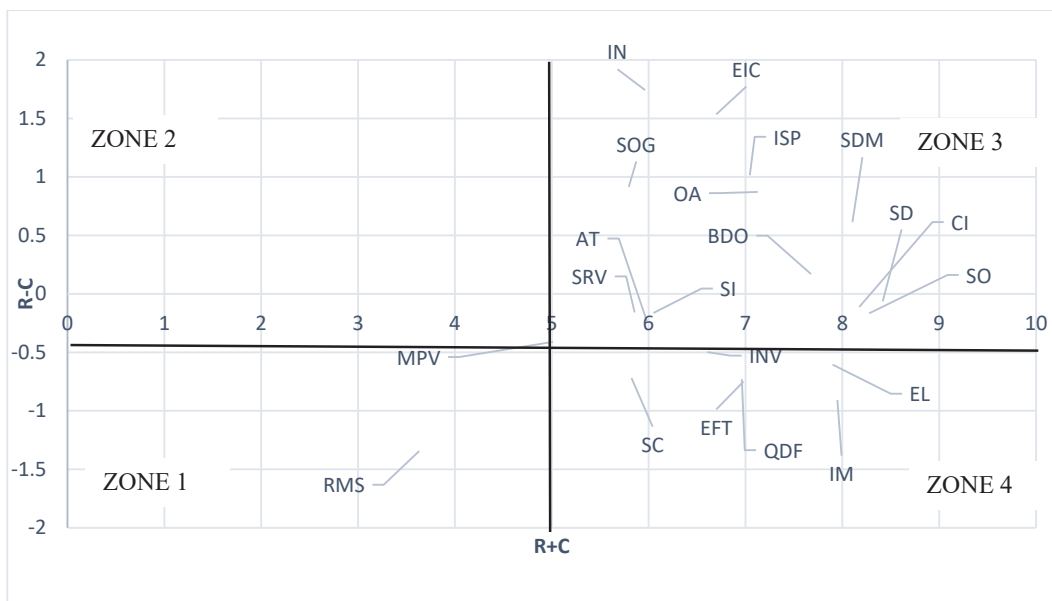


Figure 10: Zonal representation of BT-enabled CSFs for SCRS

Zone 2 represents the causal group with weaker driving power; however, no CSFs fall under this category. Zone 3 constitutes the most number of causal CSFs and represents strong driving power. The CSFs under zone 3 are most critical for the success of SCRS. The top highlights of this group are Internal Integration (IN), Efficient inter-organization communication (EIC), and Integration of Strategic Partners (ISP). Zone 4 represents the CSFs of high importance among the effect group and constitutes Invoicing (validation and approval) (INV), Efficient Logistics (Verification and Validation) (EL), Efficient Financial Transactions (EFT), Quality data for Forecasting and Analytics (QDF), Inventory Management (IM), and Smart Contract (SC). The CSFs of zone 4 need to be observed and implemented by management as soon as possible for the SCRS.

5.4 Sensitivity Analysis

Sensitivity analysis is essentially a procedure to evaluate the reliability and reliability of the methodology. Sensitivity analysis can be performed in a number of ways; one of these ways is to alter the weight assigned to a specific expert to observe how it affects the system as a whole (Gupta & Barua, 2018; Xia et al., 2015). The analysis is performed based on weights assigned as per Table 17.

Table 17: Assigned weights for sensitivity analysis

	Expert 1	Expert 2	Expert 3	Expert 4
Case 1	0.4	0.2	0.2	0.2
Case 2	0.2	0.4	0.2	0.2
Case 3	0.2	0.2	0.4	0.2
Case 4	0.2	0.2	0.2	0.4
Case 5	0.3	0.2	0.3	0.2

A separate total relationship matrix is calculated for each case and the ranking of the CSFs based on their (R_m-C_n) values is given in Table 16.

Table 18: Cause/effect CSFs ranking

Rank	Case 1		Case 2		Case 3		Case 4		Case 5	
	CSFs	R_m-C_n	CSFs	R_m-C_n	CSFs	R_m-C_n	CSFs	R_m-C_n	CSFs	R_m-C_n
1	IN	1.4943	IN	2.0652	IN	1.6542	IN	1.6442	IN	1.932
2	EIC	1.3200	EIC	1.8735	EIC	1.5559	EIC	1.2822	EIC	1.653
3	ISP	0.9635	ISP	1.1024	ISP	1.1046	SOG	0.8160	ISP	1.013
4	OA	0.8395	SOG	1.0840	SOG	0.8939	ISP	0.7991	SOG	0.884
5	SOG	0.7885	OA	0.9621	OA	0.8594	SDM	0.7747	OA	0.8345

6	SDM	0.6501	SDM	0.3549	SDM	0.5398	OA	0.7392	SDM	0.3342
7	BDO	0.1157	BDO	0.2056	BDO	0.1076	BDO	0.2349	BDO	0.3012
8	SD	0.0371	SD	0.0124	SD	0.0274	SD	0.0387	SD	0.0212
9	AT	-0.056	CI	-0.022	CI	-0.0701	AT	-0.117	CI	-0.027
10	CI	-0.170	SI	-0.024	SI	-0.1173	SO	-0.163	AT	-0.023
11	SO	-0.174	SRV	-0.059	SRV	-0.1944	CI	-0.170	SO	-0.069
12	SI	-0.242	SO	-0.077	SO	-0.2120	SI	-0.220	SI	-0.077
13	SRV	-0.279	MPV	-0.463	MPV	-0.3130	SRV	-0.260	SRV	-0.432
14	INV	-0.332	AT	-0.481	QDF	-0.4007	INV	-0.366	INV	-0.472
15	MPV	-0.419	QDF	-0.617	AT	-0.4027	MPV	-0.398	MPV	-0.661
16	EL	-0.468	EL	-0.636	INV	-0.6186	EFT	-0.491	EL	-0.589
17	EFT	-0.468	INV	-0.671	SC	-0.6971	SC	-0.561	QDF	-0.633
18	SC	-0.608	IM	-0.918	EL	-0.701	EL	-0.567	IM	-0.932
19	QDF	-0.838	SC	-0.930	IM	-0.8878	IM	-0.759	EFT	-0.938
20	IM	-0.963	EFT	-1.174	EFT	-0.8958	QDF	-0.927	SC	-1.153
21	RMS	-1.186	RMS	-1.611	RMS	-1.2320	RMS	-1.242	RMS	-1.625

The sensitivity study demonstrates that the outcomes from the four alternative scenarios were not biased. Table 18 demonstrates unequivocally that in each of the four circumstances IN and EIC occupy the first two ranks, and RMS occupies the last rank in all five cases. The analysis clearly shows that there are no biases involved and there is a similarity in cause and effect groups thus, increasing the robustness of the result obtained.