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# Modelling Challenges of Blockchain Technology enabled Healthcare Sustainable Supply Chain Management: A Modified-Total Interpretive Structural Modelling approach

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## Abstract

Blockchain technology (BCT) is beneficial for the Healthcare Sustainable Supply Chain (HSSC), and the adoption of this technology provides many benefits improving the performance of the supply chain, effortless information sharing, mitigation of data modification, etc. On the contrary, this study focuses on the various challenges that come in the path while adopting the BCT. For this, the present study initially identified the multiple challenges from the in-depth literature review. Then, the Delphi method was applied for further analysis and scalability of each challenge. Afterward, Modified-Total Interpretive Structural Modeling (M-TISM) approach is used for identifying the criticality of challenges based on the classification of challenges into different levels. This operation provides the driving and dependence power of each challenge.Furthermore, MICMAC (Cross-Impact Matrix Multiplication Analysis) analysis was performed. At the end of the analysis, the authors found the six critical challenges related to the adoption of BCT in the Healthcare Sustainable Supply Chain (HSSC). These critical challenges are the Economical Challenge (C3), Stakeholder commitment and careful handling of BCT (C2), Combining SSCM practices to BCT(C7), Lack of government intentions to promote BCT in SCM (C6), Data Security threat (C1) and Poor infrastructure for the adoption of BCT (C4). The stakeholders of HSSC should make an effort to control them on a priority basis. In addition to this, the authors also provided the practical

implication of the study and future research direction for better adoption of BCT in the Healthcare Sustainable Supply Chain.

**keywords**: Sustainable Supply Chain Management (SSCM), blockchain technology (BCT), Modified-Total Interpretive Structural Modeling (M-TISM)

## 1. Introduction

In the current era, every firm has the objective to achieve a sustainable supply chain because of many benefits like environmental protection, reduction in transportation cost, reduction in the overhead cost of the organization, better efficiency of the firm, etc. To achieve these benefits, it is mandatory to incorporate various sustainability practices in the different phases of the supply chain. From this, multiple terms related to SSCM practice evolved, like sustainable design, sustainable packaging, sustainable purchasing, and green logistics (Srivastava & Singh 2020). All these practices are implemented at a different stage of SCM from the manufacturing of the product till the product reaches the end user (i.e., customer).

The Indian healthcare sector is producing an enormous amount of biomedical waste. Most of the items are disposable in nature rather than reusable. So healthcare enterprises are paying more attention to the reduction in disposal and waste management. COVID-19 increases waste like PPE kits, face masks, and vaccine bottles (Allison et al., 2020). During the pandemic, the demand for ventilators, medicine, and oxygen cylinders increased. To fulfill this demand is quite challenging for the hospital. Keeping an accurate inventory record, maintaining the administration record, doctor's prescription to the patients and patient medical history are very cumbersome tasks. Handling this challenging situation is critical, and blockchain technology plays an important role.

Blockchain technology (BCT) has specific characteristics that make the healthcare supply chain more productive and non-disruptive. BCT can easily manage inventory as well as administration records. Three main properties of BCT that are widely used in supply chain i.e. transparency, immutability, and proper monitoring (Vishwakarma et al., 2022). BCT provides transparency of data throughout the supply chain. This property is utilized in managing the different tasks of the healthcare sector, like patient's previous histories, managing hospital assets, and tracking medical devices and equipment (Tanwar et al.,2020). Immutability means it is impossible to modify the data; only adding data is possible. So this property provides integrity of data, and because of this, it is useful in the healthcare sector for mitigating

counterfeiting of medicine and medical products (Cole et al.,2019); doctors have trust on the record of patient medical history because this record cannot be altered (Yaqoob et al.,2020). This technology has tremendous power for tracking and monitoring the product (i.e.transperancy during transportation). BCT is a decentralized technology, which means it has several nodes from which information can be accessed and added. This enables stakeholders cumulatively work together. This brings greater transparency in logistics and transportation (Esmaeilian et al.,2020). BCT-enabled SCM has greater advantages over conventional SCM, but adoption of this technology is not an easy. Industries are facing various challenges to adopt BCT-enabled SCM. This research is an attempt to identify the various challenges of BCT-enabled HSSCM. The Modified-Total Interpretive Structural Modeling (M-TISM) approach and the MICMAC (Cross-Impact Matrix Multiplication Analysis) analysis for the data analysis. This study explores various challenges that firms face while adopting the BCT-enabled HSSCM.

This paper is organized in the following sequence. Initially, start with the introduction section, which includes the background of the research. Section 2 includes a literature review and identification of challenges. Section 3 consists of the research methodology, and it includes the M-TISM method followed by Fuzzy-MICMAC (FMICMAC) techniques. Section 4 includes the discussion part and includes results drawn after implementing the research methodology. Section 5 consists of the conclusions and recommendations that emerged from the study. Moreover, it also accommodates limitations and future scope.

## 2 Literature Review

Policymakers, academics, and business experts have recently shown significant interest in blockchain-enabled sustainable supply chains in the healthcare sector. Recent studies in this area show a comparable degree of interest in approaches among practitioners in underdeveloped nations. On the other hand, the healthcare business has less knowledge available on blockchain and sustainable supply chains. Only a small number of publications are available in the different databases, making them inaccessible to industry and policymakers. Finding the appropriate literature review for the project is crucial. For this, we utilised the search phrases "Blockchain Technology" and "Industry 4.0" or "Sustainable Supply chain" or "Circular Economy" or "Blockchain in Supply chain" for the literature article collection. The article collection uses the search keywords that were previously mentioned.

Blockchain Technology (BCT) has immense potential to improve the performance of the supply chain even if it can transform the supply chain. As current healthcare sector is facing so many challenges like counterfeit medicine, data security, and inefficient data management (Dutta et al.,2020). Adoption of BCT is the solution to these challenges. The irony is that its adoption is itself a big challenge. So the organization has to look forwards and adopt the BCT to counter the current healthcare sector challenges. The organization should have IT (information technology) infrastructure and the internet as a prerequisite for adopting BCT. In addition, the organization needs technical skilled persons who can operate it and access information from it (Abeyratne, & Monfared, 2016).

Before adopting blockchain technology, organizations must define new policies that are different from the current ones. The organization should know the purpose of implementing BCT and its objective (Biswas & Gupta, 2019). Management has a long-term commitment to the adoption of SSCM practices via BCT. Sometimes organizations lack standard methods, tools, and techniques to adopt BCT and fail to measure the firm's sustainable performance (Andoni et al., 2019). Sometimes policymakers of the organization don't want to share information with every stakeholder because of confidentiality reasons, but this facility is not available in BCT (Hughes et al., 2019). Consequently, it creates problems in collaboration and communication. From the literature, it is found that there is less information is available about the adoption of Blockchain Technology (BCT) enabled HSSCM. Blockchain Technology (BCT) allows HSSCM to be put into practise, but there are still obstacles to overcome along the way.

### 2.1 Identification of Challenges

The literature review section describes the challenges associated with adopting BCT in the organization. From the in-depth literature and consultation with experts, ten challenges are identified and placed in the Table-1.

**Table1. Challenges to adopt Blockchain Technology**

| S.N. | Challenges | References |
|---|---|---|
| C1 | Data Security threat | (Siddiqui et al.,2020), (Gurtu &Johny, 2019), ( Akram et.al., 2020) |
| C2 | Stakeholder commitment and careful handling of BCT | (Rane et al.,2020)( Kouhizadeh et al.,2021), (Meidayanti & Arkeman,2019),( Rejeb et al., 2021) |

| | | |
|---|---|---|
| C3 | Economical Challenge | (Gurtu & Johny,2019), (Patel et al.,2017), (Wang et al., 2019), (Alangot & Achuthan ,2017) |
| C4 | Poor infrastructure for adoption of BCT | (Morabito 2017), (Yaeger et al.,2019),(Zelbst, et al.,2019), (Alangot & Achuthan ,2017) |
| C5 | Lack of skilled persons | (Alangot & Achuthan ,2017) |
| C6 | Lack of government intention to promote BCT in SCM | (Kouhizadeh et al.,2021), (Dutta et al.,2020), Biswas & Gupta, 2019) |
| C7 | Combining SSCM practices to BCT | (Behnke & Janssen, 2019),(Meng &Qian,2018), (Alangot & Achuthan ,2017), (Morkunas et al., 2019) |
| C8 | Lack of external stakeholders' involvement | (Meidayanti & Arkeman,2019), (Rejeb et al.,2021), (Morkunas et al.,2019), (Bag et al.,2020) |
| C9 | Market barriers and uncertainty | (Bag et al.,2020),(Zelbst, et al.,2019) |
| C10 | Cultural differences of supply chain partners | (Patel et al.,2017), (Wang et al., 2019), ), (Zelbst, et al.,2019) (Bag et al.,2020) |

***Data Security threat***- In this digital era, digital security threats like hacking of data or information always exist. Confidential information can be a leak that proves harmful to the organization.

***Stakeholder commitment and careful handling of BCT-*** The policymakers and the managers should be committed to the organization. They should not leave the organization before at least 5-6 years of service or until BCT is fully established. In addition, they should be equally conscious about implementing SSCM practices in a firm. Every stakeholder should contribute to adopting a new policy for implementing BCT. It was observed that people resist installing new systems (Angelis & da Silva, 2019).

***Economic Challenge-*** The firm has to invest additional funds to adopt BCT. It is very challenging for firms with limited funds to bear additional costs for it. The cost incurred for two purposes, i.e., combining SSCM practices into BCT and installing BCT in the firm (Patel et al., 2017). However, the implementation of SSCM practices itself is a financial exercise.

***Poor infrastructure for the adoption of BCT-*** Adoption of BCT requires some initial level of infrastructure that includes proper internet and appropriate IT infrastructure. Those firms which do not have these basic facilities cannot go for BCT adoption (Morabito, 2017). Transactions in SCM via BCT are stored, so the firm needs appropriate storage capacity.

***Lack of skilled Persons-*** Sometimes, people negatively perceive BCT and relate this technology with cryptocurrencies. This is considered as malicious thinking. Persons should have technical knowledge and expertise in BCT. Skilled persons should operate BCT Because once you add any information, it cannot be omitted.

***Lack of government intention to promote BCT in SCM-*** Government is not supporting BCT in SCM as it is not providing any kind of incentive or any other benefit. So the firms which cannot afford BCT or facing challenges while its installations are not getting any help from the government. Similarly, the firms performing well in the BCT area are not getting any kind of reward or encouragement from the government.

***Combining SSCM practices to BCT-*** Combining SSCM practices to BCT in order to implement sustainability in the firm. But this a challenging task, and it incorporates two problems i.e., first, combining SSCM practices to BCT required technical knowledge of BCT & SSCM practices. So this can be performed by certain persons (very skilled persons). Second, this is a financial exercise, and the firm has incurred additional cost.

***Lack of external stakeholder Involvement-*** Generally, external stakeholders have different objective that are irrespective of propagating sustainability. In addition, the firm doesn't want to share its information with external stakeholders because of confidentiality reasons. So persons who have a conflict of interest face problems while using BCT.

***Market barriers and Uncertainty-*** Adoption of BCT and accommodating SSCM practices in BCT are time-consuming exercises. It may influence the current firm position in this competitive market. Its result is a delay in the supply of goods, consequently unfulfilled demands, decreased future sales, etc.

***Cultural differences of supply chain partners-*** As BCT provide multiple nodes to stakeholders for accessing and adding information. It was observed that persons belonging to different cultures and geographical locations might not have a similar attitude toward accepting BCT.

This study explains the challenges that need to be conquered by doing a review of prior research and making use of the Delphi approach. The perspectives of a number of industry professionals indicate that the stakeholders, the policies of the government, and the uncertainties of the market all have a significant influence on the supply chain. As a result, this study takes into consideration the difficulties that are connected to them.Modified Total Interpretive Structural Modeling (M-TISM) technique is used to identify crucial challenges.

## 3. Methodologies

This section includes the analysis of identified challenges and the analysis is done via MCDM techniques. Techniques mainly involved are M-TISM method followed by fuzzy MICMAC (FMICMAC) analysis. So this section is further classified into two more different section whose description is given below.

1 The first section consists of the implementation of M-TISM method. So this section contains the mapping of various challenges, followed by the formation of the initial matrix and final reachability matrix.

2 The second section consists of the implementation of Fuzzy MICMAC techniques. So this section also contains the mapping of challenges, followed by the formation of the initial and final fuzzy reachability matrix. In addition to this, driving –the dependency diagram is plotted.

### 3.1 Modified Total Interpretive Structural Modeling (M-TISM)

The M-TISM technique is an up-gradation of the Total Interpretive Structural Model (TISM) and Interpretive Structural Model (ISM) (Sushil, 2019). The purpose of preferring M-TISM method over Total Interpretive Structural Model and Interpretive Structural Model (ISM) is because it conceptualizes the model and proper hierarchical structure. Moreover, TISM and ISM methods check transitivity relations separately; sometimes, it is iterative. This makes the problem complex. The M-TISM technique performs reachability and transitivity checks in a

single step (Kamble et al., 2019). The step involved in the M-TISM technique are discussed below.

**STEP 1:** In this step, all the challenges are identified from the literature and consultation with experts. A total of fifteen experts are taken in this study, of which eight have more than twelve years of experience in the healthcare sector and are currently using BCT in their firms. Similarly, the remaining seven persons have more than five years of experience.

**STEP 2:** This step explores the relationship among individual challenges. This relationship is called the contextual relationship. We want to find out how one challenge influences the other. The contextual relationship among all identified inhibitors is represented.

**STEP 3:** This step interprets the relation among challenges and finds out the cause behind the relationship. Moreover, the M-TISM technique find out "why" and "how" related questions, which the conventional TISM and ISM method don't consider.

**STEP 4:** This step includes the formation of a reachability matrix and simultaneously performing the transitivity check. We must explore the relationship between these two challenges for entry into the matrix. If a relationship exists, we put "Y" in the matrix (i.e., Yes) and "N" for no relationship. Then check for the transitivity (i.e., if A is in a relationship with B and B is in a relationship with C, then A will be in a relationship with C). In the end, All the "Y" should be replaced by 1 and all "N" replaced by 0. Based on these thing reachability matrix is formed as shown in Table 2. Entries in it are in the form of "Y" and "N". Table 3 presents the final reachability matrix. Entries in it are in the form of "1" and "0".

**Table 2. Structural self-interaction matrix**

| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 |
|---|---|---|---|---|---|---|---|---|---|---|
| C1 | - | N | N | Y | N | Y | N | N | N | Y |
| C2 | Y | - | N | N | Y | N | N | Y | N | Y |
| C3 | Y | N | - | Y | N | Y | N | N | Y | N |
| C4 | Y | N | Y | - | N | Y | N | N | N | N |
| C5 | Y | N | Y | Y | - | N | N | N | N | N |
| C6 | N | N | N | N | N | - | Y | N | N | N |
| C7 | N | Y | Y | Y | Y | N | - | N | N | N |
| C8 | N | Y | N | N | N | N | N | - | N | Y |
| C9 | Y | N | N | N | N | N | Y | N | - | N |
| C10 | Y | N | N | N | Y | N | N | N | N | - |

**Table 3. Final Reachability Matrix**

| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 |
|---|---|---|---|---|---|---|---|---|---|---|
| C1 | - | 0 | 1* | 1 | 1* | 1 | 1* | 0 | 0 | 1 |
| C2 | 1 | - | 1* | 1* | 1 | 1* | 1* | 1 | 0 | 1 |
| C3 | 1 | 0 | - | 1 | 1* | 1 | 1* | 0 | 1 | 1* |
| C4 | 1 | 0 | 1 | - | 1* | 1 | 1* | 0 | 1* | 1* |
| C5 | 1 | 0 | 1 | 1 | - | 1* | 1* | 0 | 1* | 1* |
| C6 | 0 | 1* | 1* | 1* | 1* | - | 1 | 0 | 0 | 0 |
| C7 | 1* | 1 | 1 | 1 | 1 | 1* | - | 1* | 1* | 1* |
| C8 | 1* | 1 | 1* | 1* | 1* | 1* | 1* | - | 1* | 1 |
| C9 | 1 | 0 | 1* | 1* | 1* | 1* | 1 | 0 | - | 1* |
| C10 | 1 | 0 | 1* | 1* | 1 | 1* | 1* | 0 | 1* | - |

**STEP 5: Level partitioning and development of model**

This step classifies all challenges into different levels based on their influencing power. Afterthat development of the model takes place. Challenges classification follows the same methodology as ISM and TISM methods. After calculating the cumulative score of deriving and dependence power of each challenges. They have been classified into various levels. This process comprises of identification of reachability set and antecedent sets. Reachability set consists of the challenge itself and the other challenges it may impact, whereas the antecedent set consists of the challenge itself and the other challenge that may affect it. These two common elements are taken, and they are called as intersection set. Fixation of level is done via exact matching of the intersection set with the reachability set, then eliminating those values. This process is repeated continuously until all the level is decided. After performing all these steps in the final reachability matrix, the level of each individual challenge are identified, which is mentioned in Table 4.

**Table 4. Classification of challenges into different levels**

| Challenge Code | Name of Challenge | Level Partitioning |
|---|---|---|
| C3 | Economical Challenge | 5 |
| C2 | Stakeholder commitment and careful handling of BCT | 5 |
| C7 | Combining SSCM practices to BCT | 5 |
| C6 | Lack of government intention to promote BCT in SCM | 4 |
| C1 | Data Security threat | 4 |
| C4 | Poor infrastructure for adoption of BCT | 4 |
| C8 | Lack of external stakeholders' involvement | 3 |
| C5 | Lack of skilled persons | 3 |
| C10 | Cultural differences of supply chain partners | 2 |
| C9 | Market barriers and uncertainty | 1 |

After the level partitioning next step is to plot the model. In this exercise, we get 5 levels of all the challenges. In this, 3 challenges at the bottom, i.e., level 5, and 1 at the top, i.e., level 1. Levels are sequenced in the increasing power criticality i.e. level 5 is most crucial and level 1 least crucial. According to this rule, Economic Challenge (C3), Stakeholder commitment and careful handling of BCT(C2), and Combining SSCM practices to BCT (C7) are the most crucial challenges. Market barriers and uncertainty(C9) and Cultural differences of supply chain partners(C10) are the least crucial challenges. The remaining location (i.e., level) of challenges are shown in Figure 1.

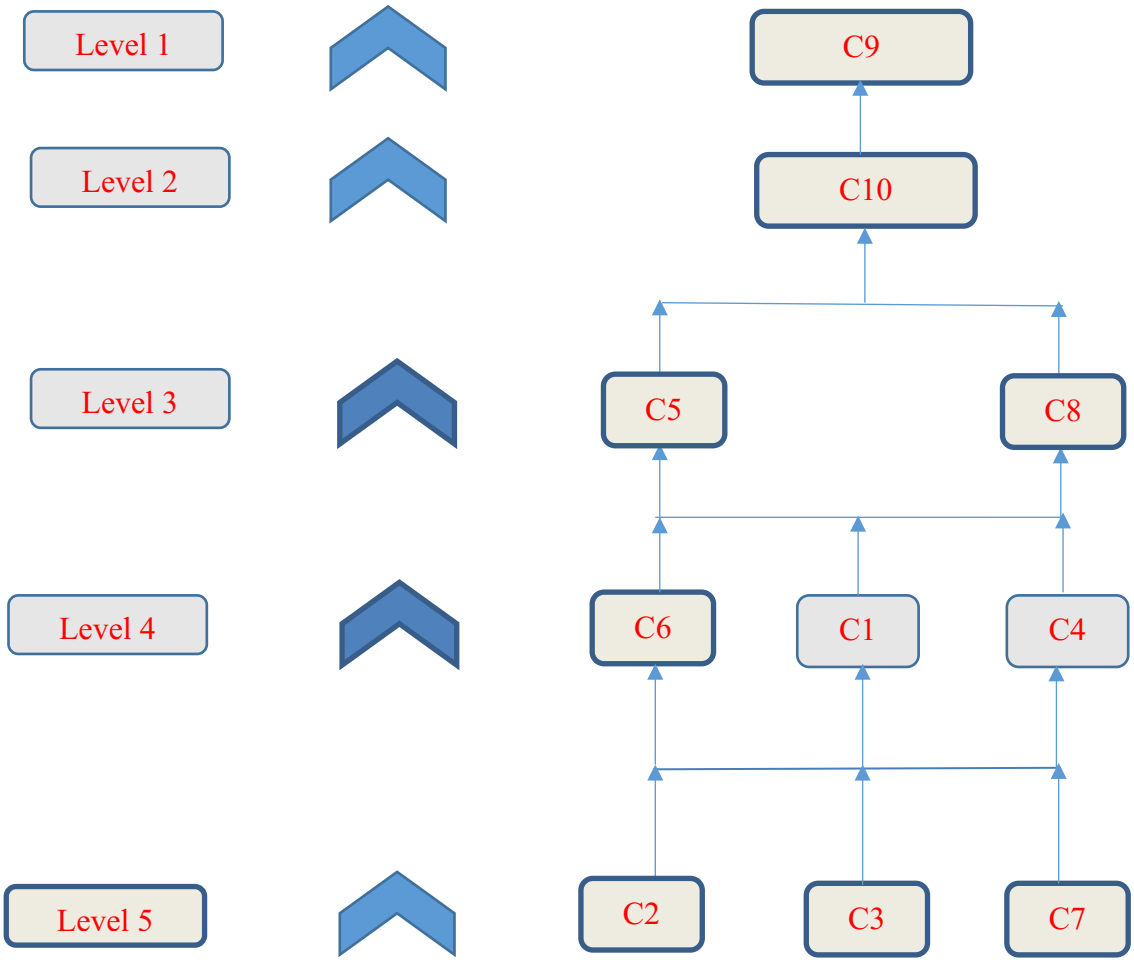


**Figure 1. Level Partitioning model**

### 3.2 Fuzzy-MICMAC (FMICMAC) Analysis

In the M-TISM method, 0 and 1 are used to show the association between the two challenges. However, there is the possibility to explore this association in deeper with by using FMICMAC (Fuzzy- MICMAC) technique. The association can be categorized into very strong, strong, low and so on. The fuzzy theory deals with this equivocalness and weakness in the decision-making cycle (Zadeh 1965). Experts opinions are taken for converting the linguistic judgments into fuzzy numbers. FMICMAC is preferred over the conventional MICMAC method by the authors because FMICMAC provides the flexibility to scale challenges into six values (i.e. 0,0.1,0.3,0.5,0.7,0.9). However, conventional MICMAC categorizes into two ways (i.e., 0 and 1). So opinions of the experts are well recorded in FMICMAC over conventional MICMAC.

In the FMICMAC method, fuzzy multiplication occurs; in the traditional MICMAC method, normal multiplication occurs.

The scaling of challenges is done by taking 6 values. These are [0, 0.1, 0.3, 0.5, 0.7 and 0.9], and the meaning corresponding to these values are [no relationship, negligible relationship, medium relationship, high relationship, and very high relationship], respectively. The values obtained from the expert's opinions are then superimposed on the binary direct reachability matrix (BDRM) to obtain a fuzzy direct reachability matrix (FDRM), which is given in Table 5.

**Table 5. Fuzzy direct reachability matrix (FDRM)**

| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 |
|---|---|---|---|---|---|---|---|---|---|---|
| C1 | 0 | 0.3 | 0.1 | 0.1 | 0.3 | 0.3 | 0.3 | 0.3 | 0.1 | 0.3 |
| C2 | 0.7 | 0 | 0.1 | 0.7 | 0.3 | 0.9 | 0.5 | 0.9 | 0.1 | 0.3 |
| C3 | 0.7 | 0.1 | 0 | 0.3 | 0.3 | 0.7 | 0.3 | 0.9 | 0.7 | 0.3 |
| C4 | 0.1 | 0 | 0.3 | 0 | 0.5 | 0.3 | 0.3 | 0.5 | 0.5 | 0.7 |
| C5 | 0.3 | 0.3 | 0.1 | 0 | 0 | 0.7 | 0.7 | 0 | 0.3 | 0.3 |
| C6 | 0.3 | 0.3 | 0.9 | 0.5 | 0.7 | 0 | 0.5 | 0.3 | 0.3 | 0.5 |
| C7 | 0.7 | 0.1 | 0.3 | 0.7 | 0.1 | 0.5 | 0 | 0.7 | 0.1 | 0.9 |
| C8 | 0.3 | 0.1 | 0.5 | 0.1 | 0.3 | 0.5 | 0.9 | 0 | 0.7 | 0.3 |
| C9 | 0.3 | 0 | 0.3 | 0.5 | 0.3 | 0.1 | 0.5 | 0.7 | 0 | 0.3 |
| C10 | 0.1 | 0 | 0.5 | 0.7 | 0.1 | 0 | 0.3 | 0 | 0.9 | 0 |

In FMICMAC analysis, fuzzy matrix multiplication occurs. This multiplication process is quite different from conventional matrix multiplication (Sarkar and Panchal, 2015) (Patidar et al.,2017). According to the fuzzy multiplication rule, the product of two fuzzy matrices is also a fuzzy matrix (Khan & Haleem, 2012). This multiplication process is described below in Fuzzy Multiplication Equation in the form of matrix A & B.

Fuzzy Multiplication Equation as shown below in equation in (i)

$$AB = Max\{Min(a_{ij}, b_{ij})\} \ldots\ldots\ldots\ldots\ldots\ldots\text{(i)}$$

Where,

$$A = (a_{ij})$$

$$B = (b_{ij})$$

The FDRM is taken as the preliminary matrix to start the procedure. The matrix is repetitively multiplied and iterated. This process continues till the values of driving, and the dependence power stabilizes.

These values are plotted in table 5 below. The dependence and driving power of elements are found in a similar way as earlier, i.e., they are obtained by summing up the columns and the rows of the final fuzzy reachability matrix, respectively. Table 6 below presents the final fuzzy reachability matrix.

**Table 6. Fuzzy stabilized matrix**

| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | **Driving Power** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C1 | 0 | 0.3 | 0.1 | 0.3 | 0.5 | 0.3 | 0.7 | 0.3 | 0.3 | 0.5 | 3.3 |
| C2 | 0.7 | 0 | 0.1 | 0.7 | 0.3 | 0.9 | 0.5 | 0.9 | 0.1 | 0.3 | 4.5 |
| C3 | 0.7 | 0.3 | 0 | 0.7 | 0.3 | 0.3 | 0.3 | 0.9 | 0.7 | 0.3 | 4.5 |
| C4 | 0.3 | 0 | 0.5 | 0 | 0.7 | 0.3 | 0.3 | 0.3 | 0.5 | 0.3 | 3.2 |
| C5 | 0.3 | 0.1 | 0.1 | 0 | 0 | 0.9 | 0.3 | 0 | 0.3 | 0.3 | 2.3 |
| C6 | 0.3 | 0.3 | 0.7 | 0.7 | 0.9 | 0 | 0.5 | 0.3 | 0.3 | 0.5 | 4.5 |
| C7 | 0.9 | 0.1 | 0.3 | 0.7 | 0.1 | 0.5 | 0 | 0.9 | 0.1 | 0.9 | 4.5 |
| C8 | 0.3 | 0.1 | 0.3 | 0.1 | 0.1 | 0.7 | 0.7 | 0 | 0.7 | 0.1 | 3.1 |
| C9 | 0.3 | 0 | 0.3 | 0.5 | 0.3 | 0.1 | 0.5 | 0.7 | 0 | 0.3 | 3 |
| C10 | 0.3 | 0 | 0.3 | 0.5 | 0.1 | 0 | 0.3 | 0 | 0.9 | 0 | 2.4 |
| **Dependence Power** | 4.1 | 1.2 | 2.7 | 4.2 | 3.3 | 4 | 4.1 | 4.3 | 3.9 | 3.5 | 34.4 |

### 3.3 Findings from fuzzy MICMAC analysis

After performing the fuzzy MICMAC analysis, we get each individual element's driving power and dependence in decimal form. Based on these values of dependence and driving power, all elements are classified into 4 sections. Figure 2 below presents these sections in quadrant forms i,e I, II, III, and IV. The name of these quadrants are autonomous, dependent, linkage, and independent elements.

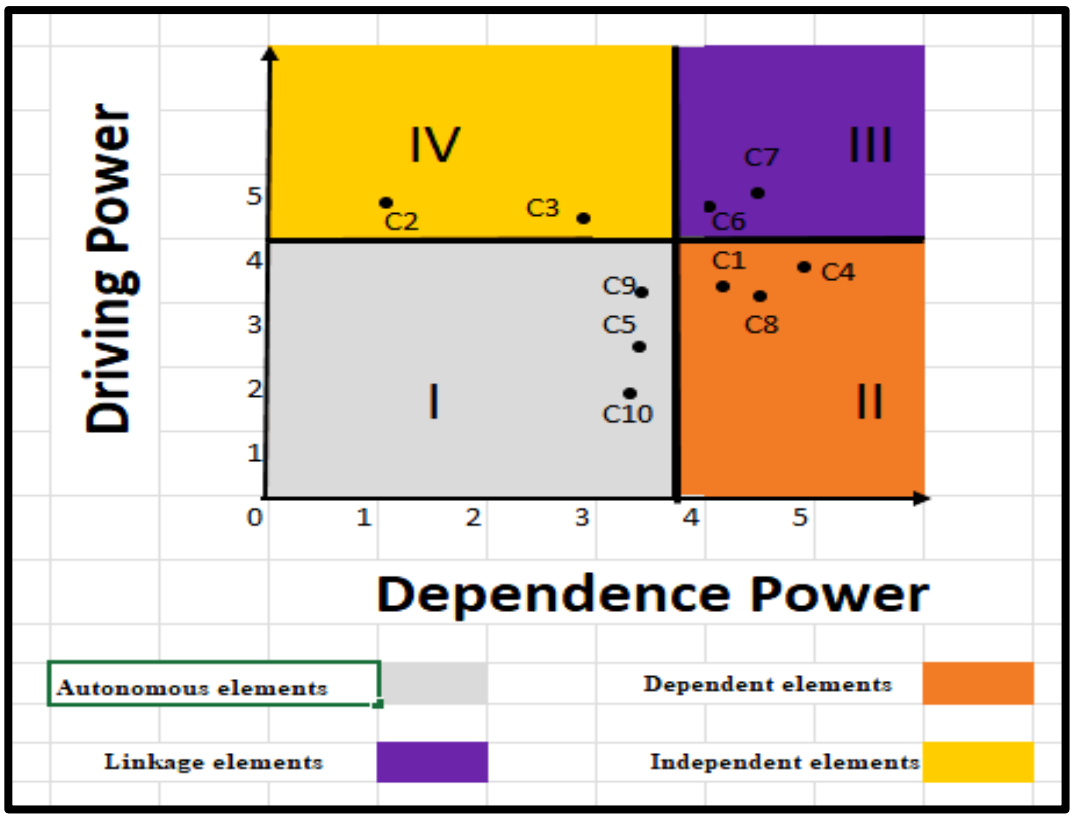


**Figure 2. Driving-dependence power diagram.**

***Autonomous elements***

These are the first quadrant elements having less driving power and less dependence power. These are put in the first quadrant. C5, C9, and C10 challenges in it. These challenges belong to level 1,2,3.

***Dependent elements***

These are the second quadrant elements with high dependence and low driving power. The dependent challenges are the least crucial as they have low driving power. This leads to the fact that they are not supporting any other challenges. It contains C1,C8, & C4 challenges.

***Linkage elements***

Linkage elements are the third quadrant elements with high dependence and driving power. This quadrant includes C6 and C7 challenges. This supports the result of the M-TISM method as these challenges belong to the higher level, i.e., level 4 and level 5.

***Independent elements***

These are the fourth quadrant elements; as their name suggests, they are independent elements or have low dependencies power. But they have high driving power. So they can influence the other elements. This quadrant includes three different types of challenges. These are C1 and C2. This supports the result of the M-TISM method as these challenges belong to the higher level, i.e., level 4 and level 5.

## 4. Discussion

This work comprises of identification of challenges for the adoption of BCT. It identified 10 challenges from the literature. These challenges are shared with the experts, and their views are taken. Their opinion is in the form of binary digits and fuzzy numbers (i.e., between 0 to 1, in the form of the decimal). All these are required to scale the M-TISM technique and FMICMAC analysis. The objective of this exercise is to investigate the criticalness of the challenges. The M-TISM method classified the challenges into 5 levels,l, i.e., level 1 to level 5, where level 5 is the most critical and level 1 is the most dependable challenge. After that, FMICMAC analysis is performed. The purpose of this exercise is to categorize the challenges into four sections based on their driving and dependence power values. This practice helps analyze each challenge's criticalness and finally leads to the classification of challenges into four quadrants, i.e., autonomous, dependent, linkage, and independent elements. In that independent and linkage elements are responsible for driving the other challenge, and that cause they are considered the critical elements. Results reveal that all independent and linkage elements are located at level 4 and level 5 in the M-TISM model (i,e.C2, C3, C6 &C7 challenges). Therefore, FMICMAC technique supports the result of the M-TISM method. This research focuses on the challenges the firm has to face in adopting BCT. As result suggested that Stakeholder commitment for blockchain technology adoption is a key challenge in addition of economic stability of the company and skilled manpower. These challenges should be eliminated by utiziliznf the best practices and government support. Healthcare sustainable supply chain allows the team of doctors to classify and categorize the patients based on their common genomic data, age, or gender (Esmaeilzadeh & Mirzaei, 2019). The timestamp feature of blockchain maintains the record of the treatment provided to the patients on the time scale. This feature allows the doctors to verify the record of the provided treatment and identify the mistake if it happens during the treatment (Shuaib et al.,2019). Blockchain technology maintains the data (patient information and other crucial information of the organization) with complete confidentiality. Therefore, adoption of blockchain technology increases the

efficiency and effectiveness of patient monitoring, and it provides ease to medical practitioners in many ways like monitoring of data and sharing of data.

## 5. Practical and research implication of the proposed study

This study suggests that decision-makers of healthcare SCM should concentrate on the critical challenges and try to mitigate them. Adopting BCT has many benefits for the firm, like reduced lead time, on-time delivery of healthcare products, improved communication among stakeholders, better flow of information, improved traceability of items, and disruptions detected at an early stage. Hospitals are important entities in healthcare SCM, and BCT-enabled hospitals have so many benefits over conventional hospitals. This consists of efficient management, cooperation among employees, risk mitigation etc. Most importantly, the patient benefits because doctors know his medical history. BCT helps make personalized healthcare plans for patients in a hospital.

## 6. Conclusion

This paper focuses on challenges in the adoption of BCT in healthcare SCM. It identified 10 challenges from the current literature and consultation with experts. The purpose of this study is to find out those challenges that are highly influencing in nature. To investigate the influencing power and criticalness, opinions is taken from the experts for applying the MCDM technique. The M-TISM technique has been utilized for assessing the challenges. After the implementation of this technique, six challenges are obtained, which are critical in nature. These belong to levels 4 and level 5 in the model. These critical challenges are Economic Challenge (C3), Stakeholder commitment and careful handling of BCT (C2), Combining SSCM practices to BCT(C7), Lack of government intention to promote BCT in SCM (C6), Data Security threat (C1) and Poor infrastructure for adoption of BCT (C4). So these challenges are a cause of concern and must be eliminated in the near future for the easy adoption of BCT in a firm. This research has a constraint, like the expert's decision might be biased and difference in opinion (of experts) while scaling the challenges. In addition, there is a difference while giving opinions in three different forms (i,e binary digits, and fuzzy numbers) by the experts. This research is limited to BCT adoption in healthcare SCM, and the findings of this study are valid for the other sector. In the future, an extensive survey can be conducted to validate the findings of this study. The challenges in the adoption of BCT can be countered by organizing an empirical study. These challenges are different for each organization. So every organization should list these challenges and try to resolve them by conducting skill training sessions, workshops, and seminars. Organizations with skilled human resources are in a better

position to adopt the BCT. This study can be extended by applying other MCDM techniques like AHP, TOPSIS, grey theory etc. PLS-SEM can be employed on the result for examination purposes. In the near future, the researcher should also focus on the various solutions to mitigate critical challenges.

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**Appendix I: Detailed Information About Experts**

| S.N. | Expert Domain | Years of Experience | Qualification | Designation |
|---|---|---|---|---|
| 1 | IT person in Supply Chain Management firm (Using BCT) | 18 | B.E. in Computer Science | Chief Supply Chain Officer. |
| 2 | | 13 | B.E. in Computer Science | Supply Chain Analyst |
| 3 | | 7 | B.E. in Computer Science | Manager |
| 4 | | 8 | B.Tech in Information Technology | Manger |
| 5 | | 8 | B.Tech in Information Technology | Manager |
| 6 | Hospital Management | 15 | | Hospital administrator |
| 7 | | 14 | | Hospital administrator |
| 8 | | 11 | Bachelor of Hospital Management | Hospital operations administrator |
| 9 | | 9 | Bachelor of Hospital Management | Hospital operations administrator |
| 10 | Hospital Inventory | 15 | MBA | Procurement Officer |
| 11 | | 10 | MBA | Procurement Officer |
| 12 | | 14 | Ph.D. | Professor |

| | | | | |
|---|---|---|---|---|
| 13 | Academician in Supply Chain | 8 | Ph.D. | Associate Professor |
| 14 | Academician in Medical College | 13 | Ph.D. | Dean |
| 15 | | 13 | Ph.D. | Dean |

# Modelling challenges of blockchain technology enabled healthcare sustainable supply chain management: a modified-total interpretive structural modelling approach

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