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# Critical Drivers and Barriers to Blockchain Adoption in the Iraqi Construction Supply Chain: A Grey Delphi–DEMATEL Approach

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**Abstract:** Blockchain technology (BT) has recently captured the attention of researchers and practitioners in the construction sector, in particular. Researchers widely agree that blockchain is not just a buzzword, but a revolutionary technology that is revolutionizing the world of corporate management, construction companies, and their supply chain operations. Despite the remarkable progress in the use of this technology in the construction sector, blockchain applications related to operations and supply chain management (OSCM) in Iraq remain completely absent. With increasing interoperability and resource constraints, this study presents a list of obstacles to blockchain adoption. In a review of 1,176 recent articles, filtering for articles on the challenges of using blockchain in construction supply chains (CSC) yielded 86 articles. The obstacles revolve around five main themes: (1) Technology, (2) Organization, (3) Environment, (4) Trust, and (5) Acceptance. Using a Grey Delphi–DEMATEL Approach, the results concluded that there are influential obstacles, such as inadequate information sharing, concerning trust management, as well as others that are influenced, including insufficient policies in the organization, absence of technical support. Therefore, this study seeks to extend our understanding of the BT and how the companies create and capture business value with it.

**Keywords:** Construction supply chain, Blockchain technology adoption, Iraqi construction industry, Grey Delphi method, DEMATEL Technique, Drivers and obstacles.

## 1. Introduction

The digital age has led to unprecedented disruptions in business models due to the continuous advancements in information and communication technologies (ICTs) [1, 2]. Blockchain is a significant and transformative technology that is reshaping conventional business models and generating new opportunities throughout the supply chain [3-5]. The concept of blockchain is a decentralized architecture that uses cryptographic methods to ensure the secure preservation of a sequential, tamper-resistant transaction history across a network. Blockchain poses both challenges and opportunities, as it has the potential to greatly enhance transparency, accountability, trust, security, operational efficiency, and cost reduction. [6-8] . Blockchain is also seen as a way to solve supply chain management (SCM) traceability issues and build more reliable and intimate connections throughout the SCM, not only between businesses and their suppliers [5, 9, 10]. A blockchain-enabled smart contract, which is a script that may initiate a transaction, has the potential to improve supply chain management (SCM) by enabling high levels of efficiency through a decentralized operation[11-13]. However, blockchain may be used in conjunction with other state-of-the-art technologies (such as big data analytics, the internet of things, and cyber-physical systems) to have disruptive effects in all specialized sectors [14, 15]. Despite the many potential advantages of blockchain, many managers still lack a solid understanding of its related concepts, such as enablers, adoption, implementation, etc. There are still unresolved issues about how they can guarantee that blockchain benefits their companies and the supply chain management.

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According to OSCM, blockchain is still in its early stages and its full potential is yet unknown. Furthermore, this contributes to the dearth of research on blockchain applications using empirical methods, such as surveys [16]. Therefore, this special issue's emphasis offers an in-depth for practitioners and researchers looking into how blockchain might add value to OSCM. This special section specifically aims to clarify and thoroughly comprehend how blockchain interacts with and influences novel business models, changes interpersonal connections, and enhances OSCM performance and competitive advantage by identifying the obstacles to using blockchain in the Iraqi construction supply chain. The specific objectives of this study are as follows:

1. To ascertain the obstacle preventing the use of BT in supply chain management.
2. To get insight into how these obstacles interact with one another.
3. Make suggestions for BT adoption.

To help decision-makers successfully overcome blockchain hurdles, The objective of this study is to explore and clarify the cause-and-effect relationships between these elements. It helps practitioners concentrate their efforts on implementing blockchain by offering advice on which obstacles have an impact on others. To identify the primary obstacles to BT adoption in the supply chain, a review of the literature was conducted. However, the study finds significant obstacles to BT implementation throughout the supply chain, emphasizing the necessity of a causal link map to successfully overcome these obstacles. This special contribution enables enterprises to minimize these obstacles and maximize their resources, especially in Iraq. This paper's remaining sections are organized as follows: The study's background and a review of pertinent literature are given in section 2, the research methodology used in the study is described in section 3, data analysis and results are covered in Section 4, the findings are discussed in section 5, and the study's conclusion, limitations, and future scope are presented in section 6.

## 2. Research methodology

The study aims to identify the obstacles preventing the use of blockchain technology in supply chain management within the Iraqi construction sector, in addition to determining the causal relationship between them. The most important of these obstacles were identified through a survey of previous related research. The Grey Delphi method was used in this study to confirm and investigate these obstacles, and the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method was employed to assess the strength of the causal relationships among them. There are many methods for identifying obstacles, but all of them lack a precise definition of the strength of the causal relationship between them, as the Total Interpretive Structural Modelling (TISM), Interpretive Structural Modelling (ISM)[17]. Ten experts in the field of construction management participated when the Grey Delphi method was used, and five of them participated in the digital data model. A framework was developed for this study, as illustrated in Fig. 1.

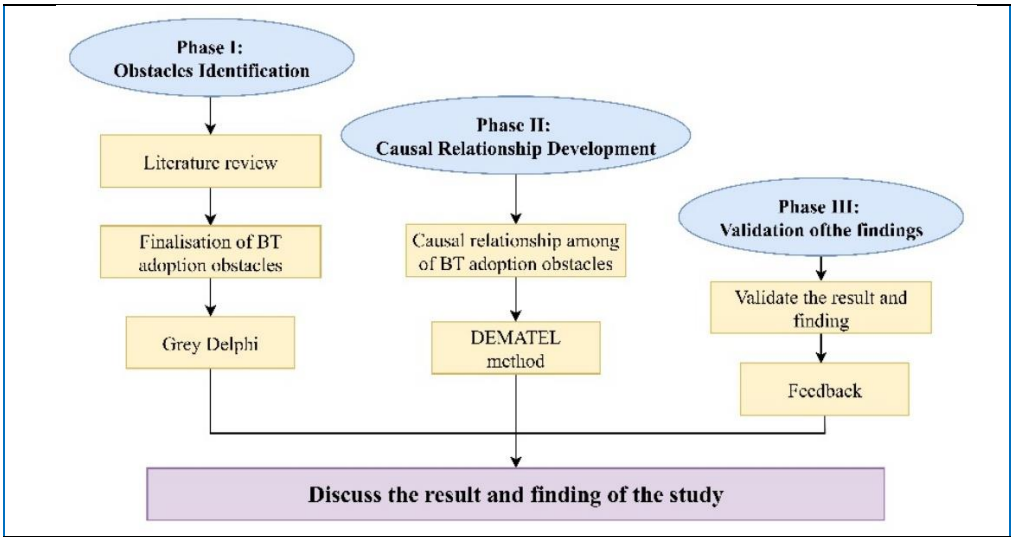



Fig. 1. A proposed study framework.

## 2.1 Grey Delphi.

The Grey Delphi Method is an investigative technique developed by [18] that combines the traditional Delphi method with the grey group theory. This technique is used to obtain expert consensus on a particular problem. The gray Delphi's steps are shown in fig. 2.

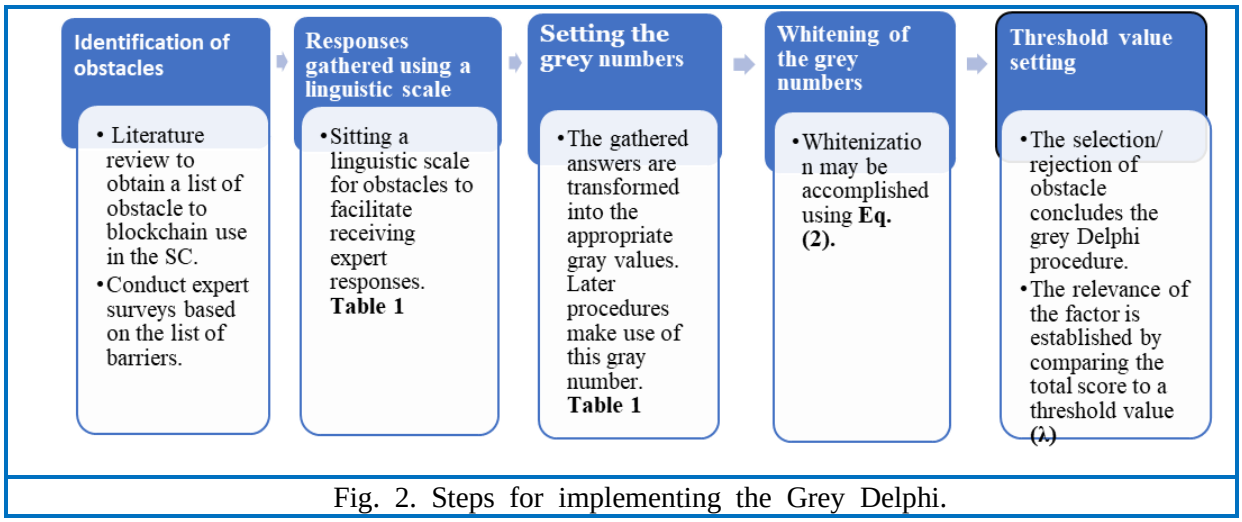



Fig. 2. Steps for implementing the Grey Delphi.

*For step three*, the evaluation of the factor ($\otimes G_i$) can be gotten as in equation Eq. (1).

$$\otimes G_i = \otimes G_i^h \sum_{h=1}^{k} \frac{1}{k} \tag{1}$$

Where $\otimes G_i$ represents the overall assessment of obstacle significance, and $\otimes G_i^h$ denotes the evaluation provided by the $h^{th}$ expert for obstacle i related to BT adoption in SC.

*For step four*, Whitenization may be accomplished using Eq. (2), when the distribution of, $\widetilde{\otimes}$ is uncertain/unknown.

$$\widetilde{\otimes} = \frac{\bar{G}\alpha G + (1-\alpha)}{\alpha + (1-\alpha)} \tag{2}$$

Were, the $\widetilde{\otimes}$ is known as whitenization, the widely used value of $\boldsymbol{\alpha}$ **is 0.5**. whose value equals the weighted mean.

*For step five*, the importance of a factor is determined by comparing its score to the threshold value (λ). If the $\widetilde{\otimes} < \lambda$ then the factor is rejected; else, it is selected.

Table 1. The gray numbers correspond to linguistic scales.

| Linguistic scale | Very high important | High im -portant | Medium im- portant | Low im- portant | Very low important |
|---|---|---|---|---|---|
| The symbol | (VH) | (H) | (M) | (L) | (VL) |
| Grey number | [4,5] | [3,4] | [2,3] | [1,2] | [0,1] |

## 2.2 Decision Making Trial and Evaluation Laboratory (DEMATEL).

In 1976, DEMATEL was proposed as a method for determining the causal relationships between factors. Since then, it has been extensively applied in various fields, including consumer behavior, supply chain

management, smart cities, traceability, healthcare [19, 20]. The DEMATEL technique consists of the following steps:

**Step 1:** Create the direct influence matrix. The matrix of influence between obstacles was developed through a questionnaire distributed to experts. For example, the influence between obstacles (A, B) was expressed on a scale of (0-4) by expert $K^{th}$, where the number 0 represents that there is no influence of A on B, and the number 4 indicates that the influence of A on B is very high as shown in Table 2.

Table 2. The influential score on the linguistic scale.

| Interpretation | Very high influence | High influence | Medium influence | Very low influence | No influence |
|---|---|---|---|---|---|
| Scale | 4 | 3 | 2 | 1 | 0 |

In this matrix, the diagonal element is 0 and $x_{ij}$ indicates that obstacle I has a greater impact than obstacle j. An $X^h = [x_{ij}{}^h]$ matrix is obtained for every respondent, where h stands for the $h^{th}$ expert ($1 \leq h \leq k$). The k number of matrices obtained from k experts as ($X^1$, $X^2$, $X^3$,... $X^k$).

Step 2. Utilizing the information from H experts, it creates the overall direct-relation matrix. The average matrix $A = [a_{ij}]$ is obtained using Eq. (3).

$$a_{ij} = \frac{1}{k} \sum_{h=1}^{k} x_{ij}^{h} \tag{3}$$

Step 3. Using Eq. (4) to create a normalized initial direct-relation matrix.

$$D = A.S \tag{4}$$

Where $$S = \left( \max_{1 \leq i \leq n} \sum_{j=1}^{n} a_{ij} \right)^{-1}$$

Step 4. Using Eq. (5) create the total relation matrix (T).

$$T = \frac{D}{(I - D)^{-1}} \tag{5}$$

Where, *(I)* represents identity matrix.

Step 5. By Apply Eq. (6) and (7) to determine the causal parameters:

$$C_j = \sum_{i=1}^{n} t_{ij} \; for \; all \; j \tag{6}$$

$$R_i = \sum_{j=1}^{n} t_{ij} \; for \; all \; i \tag{7}$$

Where *Cj* denotes the column-wise summation, and *Ri* represents the row-wise summation.

Step 6. The effect score and prominence are determined using Eq. (8) and (9):

$$E_i = R_i - C_i \tag{8}$$

$$P_i = R_i + C_i \tag{9}$$

The effect score (*Ei*) displays the net impact of obstacles on the system, whereas the prominence score (*Pi*) indicates the overall contribution of obstacle (*I*) to the system. Obstacle *I* generate a net cause when the effect score is greater than zero; otherwise, it is a net receiver. To create the causal diagram, the prominence and effect scores are shown on the x-axis and y-axis, respectively.

## 3. Results

### 3.1 Identifying the obstacles to the adoption of blockchain in SC

Ten obstacles to the use of blockchain technology in supply chain management were identified through a comprehensive literature review within the Scopus database. The research results are presented in Table (3). The results were presented to experts for evaluation. Table 4 shows the survey results in the form of a linguistic scale. The experts' linguistic weight for each obstacle was converted into a gray number, as shown in Table 1. Table 5 displays the resulting gray number matrix. Additionally, Equation (3) was used to calculate the overall gray weight of the obstacles, then, using Equation (4) to determine the crisp number for each obstacle. This number is used to select or reject the obstacle. If the crisp number is greater than 3.5, the obstacle is accepted; otherwise, it is rejected and excluded. Table 6 displays the results of the decision (Select or Reject) by displaying the crisp number and the total gray weight.

Finally, the result was 10 obstacles related to the possibility of adopting blockchain technology in the supply chain, which are presented in Table 7.

Table 3. Obstacles to the supply chain's adoption of BT.

| N | Code | Obstacles | References |
|---|---|---|---|
| 1 | OBT1 | Absence of technical support | [21, 22] |
| 2 | OBT2 | Complicated BT adoption framework | [23, 24] |
| 3 | OBT3 | Online platform cost | [25] |
| 4 | OBT4 | Concerning trust management | [26, 27] |
| 5 | OBT5 | Costly investment | [28-30] |
| 6 | OBT6 | Data security protocol | [31] |
| 7 | OBT7 | Inadequate familiarity with BT | [4, 21] |
| 8 | OBT8 | Scalability issue | [32] |
| 9 | OBT9 | Inadequate information sharing | [26, 33] |
| 10 | OBT10 | Information Security and Privacy | [31, 34, 35] |
| 11 | OBT11 | Insufficient policies in the organization | [36, 37] |
| 12 | OBT12 | Lack of advanced technologies | [22, 38, 39] |
| 13 | OBT13 | Poor communication between SC partners | [26, 27] |

Table 4. Experts' evaluation of obstacles to BT implications.

| IBT | E1 | E2 | E3 | E4 | E5 | E6 | E7 | E8 | E9 | E10 |
|---|---|---|---|---|---|---|---|---|---|---|
| OBT1 | VH | H | VH | VH | VH | M | H | VH | H | H |
| OBT2 | M | H | H | VH | VH | VH | VH | H | H | H |
| OBT3 | M | H | M | M | H | H | VH | H | L | M |
| OBT4 | H | H | M | H | H | H | VH | VH | H | VH |
| OBT5 | H | H | VH | VH | H | VH | H | VH | H | H |
| OBT6 | M | L | H | H | H | L | VH | M | M | M |
| OBT7 | M | VH | VH | H | VH | M | H | VH | H | VH |
| OBT8 | H | H | L | L | H | M | H | M | M | M |
| OBT9 | VH | VH | H | H | VH | VH | VH | VH | VH | H |
| OBT10 | H | H | M | H | H | H | VH | VH | H | VH |
| OBT11 | H | H | VH | H | VH | VH | VH | VH | VH | VH |
| OBT12 | M | VH | H | H | VH | VH | VH | H | VH | VH |
| OBT13 | VH | H | H | M | H | H | VH | H | VH | H |

Table 5. Grey matrix transformation

| ICFs | E1 | E2 | E3 | E4 | E5 | E6 | E7 | E8 | E9 | E10 |
|---|---|---|---|---|---|---|---|---|---|---|
| ICF1 | (4,5) | (3,4) | (4,5) | (4,5) | (4,5) | (2,3) | (3,4) | (4,5) | (3,4) | (3,4) |
| ICF2 | (2,3) | (3,4) | (3,4) | (4,5) | (4,5) | (4,5) | (4,5) | (3,4) | (3,4) | (3,4) |
| ICF3 | (2,3) | (3,4) | (2,3) | (2,3) | (3,4) | (3,4) | (4,5) | (3,4) | (1,2) | (2,3) |
| ICF4 | (3,4) | (3,4) | (2,3) | (3,4) | (3,4) | (3,4) | (4,5) | (4,5) | (3,4) | (4,5) |
| ICF5 | (3,4) | (3,4) | (4,5) | (4,5) | (3,4) | (4,5) | (3,4) | (4,5) | (3,4) | (3,4) |
| ICF6 | (2,3) | (1,2) | (3,4) | (3,4) | (3,4) | (1,2) | (4,5) | (2,3) | (2,3) | (2,3) |
| ICF7 | (2,3) | (4,5) | (4,5) | (3,4) | (4,5) | (2,3) | (3,4) | (4,5) | (3,4) | (4,5) |
| ICF8 | (3,4) | (3,4) | (1,2) | (1,2) | (3,4) | (2,3) | (3,4) | (2,3) | (2,3) | (2,3) |
| ICF9 | (4,5) | (4,5) | (3,4) | (3,4) | (4,5) | (4,5) | (4,5) | (4,5) | (4,5) | (3,4) |
| ICF10 | (3,4) | (3,4) | (2,3) | (3,4) | (3,4) | (3,4) | (4,5) | (4,5) | (3,4) | (4,5) |
| ICF11 | (3,4) | (3,4) | (4,5) | (3,4) | (4,5) | (4,5) | (4,5) | (4,5) | (4,5) | (4,5) |
| ICF12 | (2,3) | (4,5) | (3,4) | (3,4) | (4,5) | (4,5) | (4,5) | (3,4) | (4,5) | (4,5) |
| ICF13 | (4,5) | (3,4) | (3,4) | (2,3) | (3,4) | (3,4) | (4,5) | (3,4) | (4,5) | (3,4) |

Table 6. Findings of the Grey Delphi

| Initial Obstacles | Overall Grey Weigh | Crisp Weight | Decision | Rename |
|---|---|---|---|---|
| ICF1 | [3.4,4.4] | 3.9 | Select | OBT1 |
| ICF2 | [3.3,4.3] | 3.8 | Select | OBT2 |
| ICF3 | [2.5,3.5] | 3 | Reject | None |
| ICF4 | [3.2,4.2] | 3.7 | Select | OBT3 |
| ICF5 | [3.4,4.4] | 3.9 | Select | OBT4 |
| ICF6 | [2.3,3.3] | 2.8 | Reject | None |
| ICF7 | [3.3,4.3] | 3.8 | Select | OBT5 |
| ICF8 | [2.2,3.2] | 2.7 | Reject | None |
| ICF9 | [3.7,4.7] | 4.2 | Select | OBT6 |
| ICF10 | [3.2,4.2] | 3.7 | Select | OBT7 |
| ICF11 | [3.7,4.7] | 4.2 | Select | OBT8 |
| ICF12 | [3.5,4.5] | 4 | Select | OBT9 |
| ICF13 | [3.2,4.2] | 3.7 | Select | OBT10 |

Table 7. Final blockchain technology barriers and their descriptions.

| N | Code | Obstacles | Description |
|---|---|---|---|
| 1 | OBT1 | Absence of technical support | One of the main obstacles to SC adopting BT is a lack of technical expertise. |
| 2 | OBT2 | Complicated BT adoption framework | Since BT is still in its infancy in the SC environment, the implementation framework is insufficient. |
| 3 | OBT3 | Concerning trust management | A lack of mutual trust prevents the supply chain partners from sharing information. |
| 4 | OBT4 | Costly investment | The adoption of BT necessitates substantial investments in new infrastructure for data collection and processing, making it a costly undertaking. |
| 5 | OBT5 | Inadequate familiarity with BT | The implementation of BT within supply chain systems is hindered by the sector-specific differences in BT theories and practical applications. |
| 6 | OBT6 | Inadequate information sharing | A large number of businesses treat their data as a strategic competitive resource, which results in a reluctance to disclose vital |

| | | | |
|---|---|---|---|
| | | | information. |
| 7 | OBT7 | Information Security and Privacy | Cyber-attacks pose significant risks by enabling unauthorized access to sensitive data and facilitating its unlawful dissemination. |
| 8 | OBT8 | Insufficient policies in the organization | BT adoption compels organizations to redefine and establish new standards that address shifts in roles, responsibilities, and professional expertise. |
| 9 | OBT9 | Lack of advanced technologies | The implementation of BT in supply chains is complicated by the unavailability of standardized tools, methodological frameworks, and performance assessment metrics. |
| 10 | OBT10 | Poor communication between SC partners | A lack of effective communication among supply chain stakeholders poses a major barrier to successful BT implementation. |

## 3.2 DEMATEL Analysis.

In Table 8, the experts provide the Initial Direct Relationship Matrix (IDRM). The experts are five specialists with knowledge of blockchain, supply chain management, and technology adoption. The Normalized Relationship Matrix (NRM) is created from this IDRM by using Equation (4). Table 10 illustrates the resulting NRM. The resulting NRM is converted to a total relationship matrix (T) using Eq. (5), as shown in Table 11. To determine whether there is a substantial link between the obstacles, the threshold value has been calculated. This threshold value is calculated by summing the "standard deviation of the T matrix" and the "average of the T matrix." This threshold value supports the formation of the causal map and its differentiation. If the values in the T matrix (see Table 11) are more than the threshold value, the causal map is said to have been created. In addition to helping to prioritize one obstacle over another, this cause-and-effect map also makes it possible to exclude less significant effects from the causal effect map.

The T matrix in Table 11 generates the causal map of the adoption barriers for blockchain technology, illustrated in Fig. 3. The arrow indicates the direction of relationships and their weight, while the nodes represent the obstacles. Over the directional arrow, the relationship weight is displayed. Greater weights indicate a higher connection between the obstacles. Additionally, it displays the cause-and-effect boundaries using two distinct colors. In the total relationship matrix T, as shown in Table 12, the row-wise summation (R) and column-wise summation (C) are carried out using equations (6) and (7). It also computes the prominence and effect scores using equations (8) and (9) respectively. In Fig. 3, the causal link map is created and displayed based on the prominence and net effect score. The obstacles that were found are further divided into "influenced obstacles" and "influential obstacles." There are five influential obstacles: Inadequate information sharing, Concerning trust management, Lack of advanced technologies, Poor communication between SC partners and Costly investment.

Table 8 Initial relationship matrix

| Obst. | OBT1 | OBT2 | OBT3 | OBT4 | OBT5 | OBT6 | OBT7 | OBT8 | OBT9 | OBT10 |
|---|---|---|---|---|---|---|---|---|---|---|
| OBT1 | 0 | 0.125 | 2.125 | 1.75 | 3.625 | 1.125 | 3.25 | 3.125 | 2.125 | 1.125 |
| OBT2 | 1.125 | 0 | 2.125 | 1.625 | 0 | 3.625 | 3.125 | 3.75 | 2.125 | 2.25 |
| OBT3 | 0 | 0.125 | 0 | 1.125 | 3.125 | 3.625 | 2.375 | 2.125 | 1 | 3.125 |
| OBT4 | 0.75 | 1.125 | 2.625 | 0 | 1.5 | 1.875 | 1.125 | 0 | 0 | 1.125 |
| OBT5 | 3.25 | 0.125 | 1.125 | 2.625 | 0 | 2.125 | 1.125 | 1.75 | 3.125 | 2.125 |
| OBT6 | 1.125 | 1.125 | 3.375 | 0.125 | 4 | 0 | 0.125 | 2.125 | 2.25 | 1.25 |
| OBT7 | 1.125 | 0.125 | 3.125 | 1.375 | 2.75 | 3.75 | 0 | 1.125 | 1.125 | 2.125 |
| OBT8 | 3.125 | 2.875 | 2.25 | 1.5 | 1.625 | 3.5 | 1.125 | 0 | 2.375 | 2.5 |
| OBT9 | 2.125 | 1.75 | 3.125 | 2.75 | 2.125 | 1.125 | 0.625 | 1.125 | 0 | 1.125 |
| OBT10 | 0 | 0.375 | 3.875 | 1.125 | 1.125 | 3.125 | 3.125 | 2.625 | 0 | 0 |

Table 9 Normalized relationship matrix

| Obst. | OBT1 | OBT2 | OBT3 | OBT4 | OBT5 | OBT6 | OBT7 | OBT8 | OBT9 | OBT10 |
|---|---|---|---|---|---|---|---|---|---|---|
| OBT1 | 0 | 0.0052 | 0.089 | 0.0733 | 0.1518 | 0.0471 | 0.1361 | 0.1309 | 0.089 | 0.0471 |
| OBT2 | 0.0471 | 0 | 0.089 | 0.0681 | 0 | 0.1518 | 0.1309 | 0.1571 | 0.089 | 0.0942 |
| OBT3 | 0 | 0.0052 | 0 | 0.0471 | 0.1309 | 0.1518 | 0.0995 | 0.089 | 0.0419 | 0.1309 |
| OBT4 | 0.0314 | 0.0471 | 0.1099 | 0 | 0.0628 | 0.0785 | 0.0471 | 0 | 0 | 0.0471 |
| OBT5 | 0.1361 | 0.0052 | 0.0471 | 0.1099 | 0 | 0.089 | 0.0471 | 0.0733 | 0.1309 | 0.089 |
| OBT6 | 0.0471 | 0.0471 | 0.1414 | 0.0052 | 0.1675 | 0 | 0.0052 | 0.089 | 0.0942 | 0.0524 |
| OBT7 | 0.0471 | 0.0052 | 0.1309 | 0.0576 | 0.1152 | 0.1571 | 0 | 0.0471 | 0.0471 | 0.089 |
| OBT8 | 0.1309 | 0.1204 | 0.0942 | 0.0628 | 0.0681 | 0.1466 | 0.0471 | 0 | 0.0995 | 0.1047 |
| OBT9 | 0.089 | 0.0733 | 0.1309 | 0.1152 | 0.089 | 0.0471 | 0.0262 | 0.0471 | 0 | 0.0471 |
| OBT10 | 0 | 0.0157 | 0.1623 | 0.0471 | 0.0471 | 0.1309 | 0.1309 | 0.1099 | 0 | 0 |

Table 10 Total relationship matrix

| Obst. | OBT1 | OBT2 | OBT3 | OBT4 | OBT5 | OBT6 | OBT7 | OBT8 | OBT9 | OBT10 |
|---|---|---|---|---|---|---|---|---|---|---|
| OBT1 | 0.149 | 0.093 | 0.329 | 0.222 | 0.367 | 0.298 | 0.281 | 0.298 | 0.243 | 0.232 |
| OBT2 | 0.193 | 0.100 | 0.359 | 0.216 | 0.252 | 0.415 | 0.291 | 0.343 | 0.250 | 0.288 |
| OBT3 | 0.131 | 0.083 | 0.229 | 0.174 | 0.326 | 0.367 | 0.230 | 0.247 | 0.183 | 0.286 |
| OBT4 | 0.103 | 0.087 | 0.240 | 0.079 | 0.190 | 0.218 | 0.137 | 0.109 | 0.090 | 0.151 |
| OBT5 | 0.255 | 0.088 | 0.280 | 0.241 | 0.215 | 0.305 | 0.195 | 0.237 | 0.263 | 0.247 |
| OBT6 | 0.175 | 0.120 | 0.339 | 0.143 | 0.349 | 0.219 | 0.149 | 0.248 | 0.233 | 0.216 |
| OBT7 | 0.168 | 0.079 | 0.343 | 0.183 | 0.317 | 0.366 | 0.140 | 0.211 | 0.187 | 0.249 |
| OBT8 | 0.275 | 0.208 | 0.372 | 0.225 | 0.323 | 0.416 | 0.234 | 0.220 | 0.273 | 0.304 |
| OBT9 | 0.199 | 0.139 | 0.328 | 0.234 | 0.275 | 0.260 | 0.169 | 0.204 | 0.133 | 0.205 |
| OBT10 | 0.116 | 0.088 | 0.360 | 0.161 | 0.246 | 0.344 | 0.252 | 0.256 | 0.135 | 0.164 |

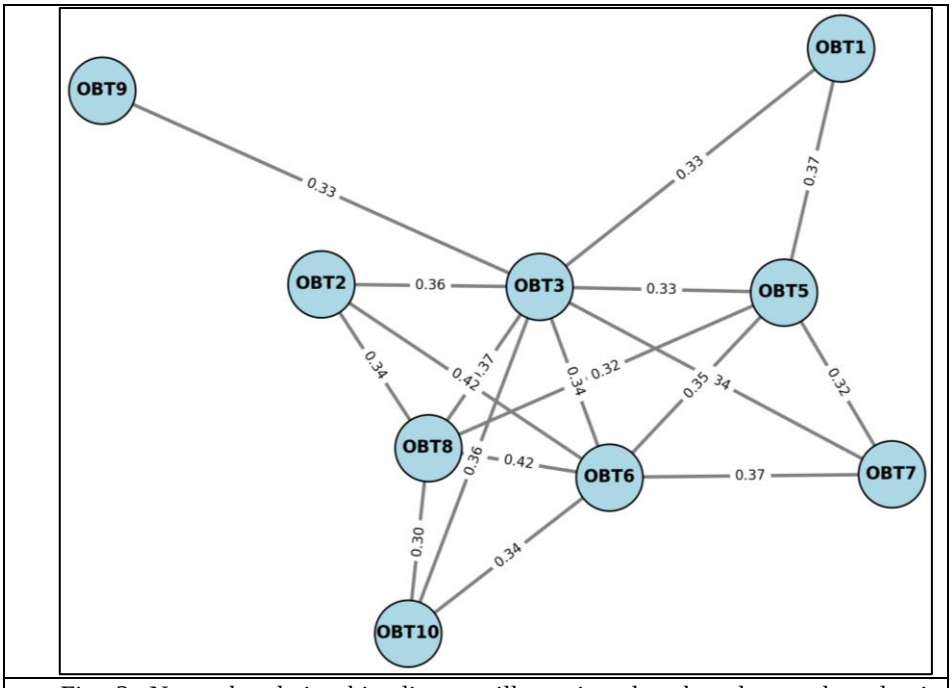



Fig. 3. Network relationship diagram illustrating the obstacles to the adopti on of BT

Table 12 Causes and consequences of barriers to BT adoption

| Obstacles | C | R | Pi | Ei | Cause/ Effect |
|---|---|---|---|---|---|
| OBT1 | 1.7647 | 2.5127 | 4.2774 | 0.748 | Cause |
| OBT2 | 1.0842 | 2.7066 | 3.7908 | 1.6224 | Cause |
| OBT3 | 3.1789 | 2.2575 | 5.4364 | -0.9214 | Effect |
| OBT4 | 1.8785 | 1.4023 | 3.2808 | -0.4762 | Effect |
| OBT5 | 2.8601 | 2.324 | 5.1841 | -0.5361 | Effect |
| OBT6 | 3.2069 | 2.1898 | 5.3967 | -1.0171 | Effect |
| OBT7 | 2.0788 | 2.2412 | 4.32 | 0.1624 | Cause |
| OBT8 | 2.3718 | 2.8507 | 5.2225 | 0.4789 | Cause |
| OBT9 | 1.9887 | 2.147 | 4.1357 | 0.1583 | Cause |
| OBT10 | 2.341 | 2.1218 | 4.4628 | -0.2192 | Effect |

More attention must be paid to these obstacles, which affect the other important ones. The “Inadequate information sharing” is the most significant obstacle and a key worry for the SC partners. Because they think this important information may be exploited, the SC partners are reluctant to share their data with other parties. Building trust among the SC stakeholders is necessary to get beyond this obstacle. The next influencing obstacle, “Concerning trust management,” is lessened by collaboration and an awareness of the demands of contemporary business situations. The SC partners' level of confidence is raised by the Blockchain's actual implementation. The third obstacle to Blockchain implementation at the SC level is the “Lack of advanced technologies,” Long-term success requires significant investment and backing from upper management. The “Poor communication between SC partners” is the next influential obstacle, this can be mitigated through effective communication with SC partners. “Costly investment” is a significant obstacle for small enterprises in developing countries like Iraq, especially in advanced technologies like Blockchain. To motivate implementation, awareness about benefits and priority should be given to developing business cases and determining their worth.

The obstacle of the influenced group consists of the: Insufficient policies in the organization, Absence of technical support, Information Security and Privacy, Inadequate familiarity with BT, Complicated BT adoption framework. Once the influencer obstacle factors are successfully removed, it should be easy to minimize these influenced variables. For example, addressing trust, communication, technological knowledge, and information sharing obstacles can lead to more effective mitigation of organizational policy, lack of knowledge, and technical obstacles.

As a result, our study has shown the causal linkages between the elements that hinder the adoption of BT, and these findings may be useful in the workplace. Because of its emphasis on developing nations, our study on the obstacles to BT deployment in Iraq is distinct and cannot be directly compared to other studies. For instance, Fig. 3 shows that the absence of advanced technology in Iraq is an obstacle that is impacted by a wide range of other factors. We recognize that this scenario may differ in other, more established economies.

## 4. Context and Implications

Due to the varying environments, incentives, and supply chain capabilities among industries, sectors, and nations, there are several obstacles to BT adoption [40]. For example, [41] highlight Dubai's government-directed policies and business readiness, while in India, key factors include organizational-level information sharing, trust, technological capability, and organizational capabilities. [22] found that technical expertise, lack of blockchain-skilled specialists, and governance mechanisms were major obstacles to blockchain adoption in the additive manufacturing field.

Considering the research we looked at, it is acceptable to assume that context matters since different industries and nations have different regulatory environments, levels of business knowledge, internal business preparedness, and different supply chain partner relationship styles. We observe that although there are some contextual differences between nations and industries, there are also some overlapping similarities that can be expected, such as in the results reported by those who discuss the importance of a

collaborative culture, which, in the absence of it, may be a common obstacle across all nations and industries.

The main barriers to BT deployment in the SC are listed in this study, along with their relationships. For supply chain management to successfully implement BT, the obstacles that have been identified should be removed. Understanding the causal links between the obstacles aids policymakers and SC managers in reducing them by identifying those that have an impact on others. According to this research, by managing the influencing group obstacles, we may influence and control the influenced group obstacles as well, giving us the information that will increase the effectiveness of overcoming such hurdles. Additionally, this study outlines the BT's needs and benefits, which encourages SC participants to apply the BT within their own SC. Managers may more effectively build their action plan and tactics when they understand the causal relationship between the hurdles.

## 5. Conclusions

The objective of this study was to determine and evaluate the causal link between adoption of BT in the SC and its obstacles. To achieve this objective, the literature analysis identified 10 main obstacles to BT in the SC. The gray Delphi approach validated and analytically completed these important obstacles to BT adoption. The causal relationship between them was subsequently established using the DEMATEL technique. The detected obstacles were divided into two groups by the selected methodology: influential and influenced. Five of the obstacles are categorized as the influenced group, while the other group, influential, consists of the remaining five obstacles. Based on the acquired cause-and-effect knowledge, managerial implications were derived from these findings.

### 5.1 Limitation

The limitations were determined via a literature review and expert comments, which is one of the study's weaknesses. Therefore, when choosing and evaluating the content, there is always an opportunity that some potential obstacles may be overlooked. Furthermore, even though the research design made an effort to minimize bias, the evaluation is dependent on expert comments, which may be prejudiced.

### 5.2 Suggestions for future research

The weaknesses can be mitigated by expanding the scope of the literature review procedure to include certain pertinent obstacles. We suggest building on this current study by conducting interviews with industry practitioners who have used BT, as well as by doing qualitative case studies and quantitative (survey) based research to further validate and improve our understanding of its hurdles. BT's supply chain and commercial possibilities make it imperative that our understanding of blockchain hurdles be further refined.

Expert comments from a developing nation (Iraq) served as the basis for this study, where obstacles may differ from those in other regions (such as developed countries in the USA and Europe), we propose that future research should clearly evaluate obstacles across various regions. Furthermore, learning across areas and economic categories will result from such comparing and benchmarking research, which will contribute to the body of knowledge and expertise. Case studies of how these obstacles were removed or lessened at the supply chain or company level could also be included in future research.

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