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# Barriers of blockchain technology adoption in viable digital supply chain

Kamar Zekhnini<sup>1\*</sup>[0000-0002-8778-9651], Anass Cherrafi<sup>1</sup>[0000-0003-2106-6909], Imane Bouhaddou<sup>1</sup>[0000-0001-9111-5556], Abla Chaouni Benabdellah<sup>1</sup>[0000-0003-2953-9109], Rakesh Raut<sup>2</sup>[0000-0002-0469-1326]

<sup>1</sup>L2M3S Laboratory, ENSAM, Moulay Ismail University, 50500 Meknes, Morocco

<sup>2</sup>Department of Operations Management, National Institute of Industrial Engineering (NITIE), Mumbai, India

\*kamar.zekhnini@gmail.com, a.cherrafi@ensam.umi.ac.ma, b\_imane@yahoo.fr, benabdellah.abla@gmail.com, rraut@nitie.ac.in

**Abstract.** In recent years, blockchain, the foundational technology of Bitcoin, has attracted substantial interest from industry and academics. Specifically, blockchain technology becomes regarded as a rapid innovation joining the global supply chain in the digital era. Adopting blockchain technology makes digital supply chain operations more transparent, safer, traceable, and resilient. Despite this rosy outlook, many barriers prevent its adoption considering the digital supply chains' viability performance. This paper aims to explore crucial barriers to the implementation of blockchain technology in viable digital supply chains. In this context, a total of 12 barriers were identified through a comprehensive literature review and discussion with team experts. This paper presents a DEMATEL-based method for investigating identified blockchain technology adoption barriers and developing a causality diagraph. The elaborated diagraph illustrates the causality relationship between barriers. This study gives stakeholders an overview of the barriers that should be prioritized and addressed to ensure Blockchain technology's successful implementation in viable digital supply chains.

**Keywords:** Blockchain technology, Digital supply chain, Viability, Sustainability, Resilience, Agility, DEMATEL.

## 1 Introduction

In recent years, industries have seen global changes due to digitalization, globalization, or natural disasters [1]. More clearly, industry 4.0 technologies directly impact performance and produce significant advancements in different industries [2]. In this context, blockchain adoption is revolutionizing many organizations [3]. Since its introduction in the financial industry, blockchain technology has given a new paradigm for creating collaborative platforms. Since then, it has been used to a variety of

industries, including supply chain, health care, corporate systems, and product lifecycle management (PLM). In this context, Blockchain technology (BT) allows digital supply chains (DSCs) to increase resilience, sustainability, and agility benefits [4]. It permits organizations to enhance viability performance. However, despite its strengths, many organizations are still doubtful about its adoption [4]. Because BT adoption has many barriers especially considering the digitalization and viability aspects.

Few authors have published scientific studies on the barriers to BT adoption. Some of the studies that have already been done are focused on Technology-Organization-Environment classification [5]. Further research focused on the construction and analysis of a systemic model of barriers [6]. Other authors have studied the BT adoption barriers in the traditional [7–9] or sustainable supply chains (SCs) [10, 11]. The scientific discussion on this subject is still ongoing, and further evidence is required before a consensus can be achieved [12]. In this context, there is no available comprehensive study where BT barriers in viable digital supply chains (VDSCs) are evaluated using Decision making trial and evaluation laboratory (DEMATEL) approach. This paper aims to fill this gap by discussing and examining the BT adoption barriers in VDSCs. First, it identifies the barriers to the adoption of BT in DSC considering the viability performance. Second, it analyzes the cause/effect relationship between 12 barriers using DEMATEL to determine each barrier's overall degree of influence over the other barriers. Finally, it discusses the findings to allow practitioners and managers to overview the barriers that should be classified as priorities to address. To sum up, the research questions discussed in this article are as follows:

- RQ1. What are the BT adoption barriers in the VDSC?
- RQ2. What are the dependencies and causalities between the studied barriers?
- RQ3. What are the hierarchical levels among these barriers?
- RQ4. What are the implications for both practitioners and decision-makers?

This article is organized as follows: in section 2, we present the methodology opted for conducting the study. Section 3 presents the literature review. Section 4 presents the application of DEMATEL for BT adoption barriers in VDSC. Section 5 analyzes and discusses the findings. Section 6 presents implications for practitioners.

## **2 Research methodology**

The goal of this paper is to assess and analyze BT barriers adoption for VDSC. Fig.1 presents an overview of the overall research methodology used in this study. It illustrates the step-by-step approach adopted to discuss the study's objective. Hence, the presented methodology comprises three phases. The first phase consists of identifying BT adoption barriers throughout the literature review and experts' validation. It consists of creating a comprehensive list of barriers that could inhibit or slow BT's adoption in the VDSCs. Hence, to address a wide range of academic productions, Elsevier, Emerald, Taylor & Francis, Springer, IEEE, Scopus, and Google Scholar databases were used to identify the related publications. The second phase is about the evaluation of the identified barriers. At this point, the previously established

BT barriers will be thoroughly investigated using the DEMATEL approach. This approach is implemented considering five steps:

- Aggregating results and establishing pairwise direct- relation matrix;
- Determining the initial influencing matrix (N) by normalizing;
- Calculating the total relation matrix (T);
- Determining column and rows sums from the total relation matrices;
- And (5) Determining the net effect and overall prominence values.

The third and final phase includes analyzing and discussing the preceding phases and presenting some managerial implications and directions for future research.

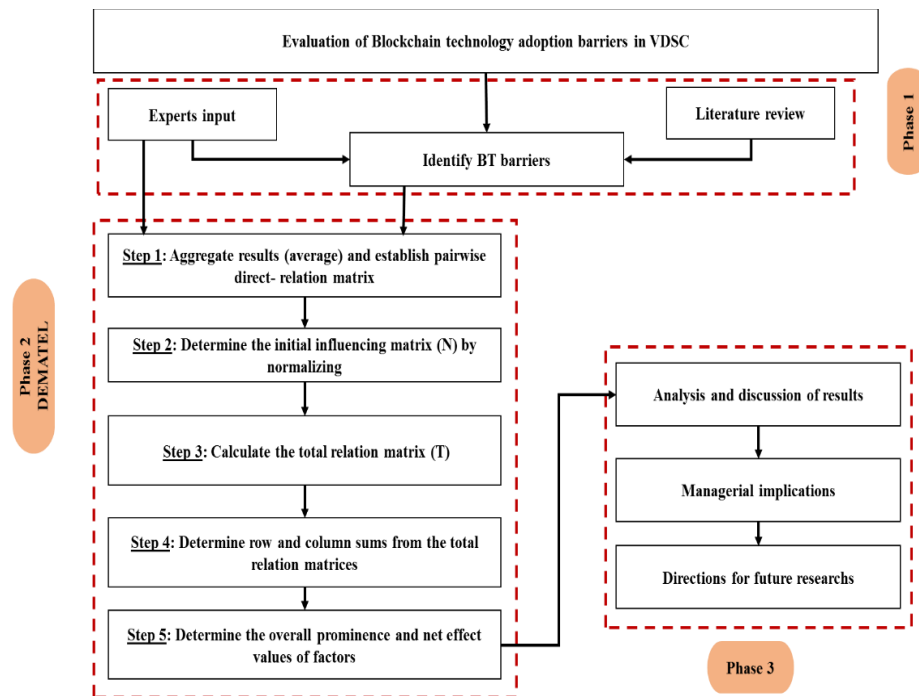


Fig. 1. The adopted methodology for this research

### 3 Literature review

#### 3.1 Blockchain technology

Blockchain technology (BT) (called distributed ledger technology) is a peer-to-peer IT network maintaining digital asset transactions records. It uses distributed ledgers instead of standard centralized databases [4] which are connected by cryptographic methods through a consensus mechanism [13]. In other words, a blockchain refers to a chain of blocks. Those blocks consist of digital bits of data such as transactions,

participating actors, and distinction from other blocks. The chain corresponds to their storage in a distributed database [14]. These decentralized databases can be distributed through a network of different geographies, sites, or organizations [15]. Besides, Blockchain includes nodes that classify transactions into blocks [14]. It is the nodes' role to determine the transactions' validity and if the transactions should be stored in the blockchain. Add to this, in ledgers, a single actor cannot change or erase block transactions [14]. Hence, BT's key innovation lies in its capacity to openly and publicly verify, register, and share transactions in encrypted and unchangeable ledgers [15]. Thus, Blockchain offers a digitally open and transparent public ledger for all stakeholders in a timed data architecture [14]. The transparent, open, decentralized, and cryptographic essence of BT generates trust. This provides many security advantages [4] and can significantly reduce costs and improve performance [16]. According to [17], Blockchain allows organizations with four capabilities. First, it provides a shared ledger wherein data architecture is locally shared and distributed among various participants. In addition, permissioning capability guarantees data privacy and transparency by securing and protecting transactions. Moreover, smart contracts refer to storing organizations' terms in databases to carry out transactions. Finally, consensus transactions are supported by relevant users who guarantee data traceability and stability. These capabilities depend on the used platform. For instance, Blockchains permit the emergence of decentralized cryptocurrencies like Bitcoin, the self-execution of digital contracts ("smart contracts"), and smart properties that may be managed through the internet [15].

### **3.2 Blockchain technology in viable digital supply chain**

Due to technical advances, particularly in information management, the use of BT is essential to help handle supply chain processes [16, 18]. Nevertheless, blockchain technology's introduction brings a modern viewpoint about managing the supply chain [19, 20]. SCs are becoming more unpredictable day after day due to numerous factors such as human error, disrupted systems, and environmental issues [21]. Therefore, the Traditional Supply Chain (TSC) struggled to satisfy the customer's demand. The current trend consists of having interconnected, smarter, agile, sustainable, and resilient supply chains [20]. This SC's novel trend refers to have more VDSCs. This last can be defined as an intelligent, adaptable value-added network that can respond agilely to positive changes, be resilient and recover from disruption, and survive considering a sustainable environment. Thus, viability is a fundamental SC asset covering three dimensions, i.e., resilience, sustainability, and agility [22]. In the following, we identify the BT use in the different dimensions.

#### **BT for Resilient Digital Supply chain**

BT, designed as a new kind of revolutionary internet technology, could help in dealing with intermediary intervention risks, namely violated privacy, hacking, political instability, financial institutions' volatility, pricey compliance with government regulations, and contractual conflicts [4]. BT helps participating actors to monitor

digital data, considering various other functions, like smart contracts to prevent and respond to digital disruptions, such as fraud [16]. BCT may promote resilience approaches during disruption to ensure DSC' communication, agility, efficiency, and visibility [23].

#### **BT for sustainable digital Supply chain**

The relevance of considering sustainability is outlined in the SCM literature [17]. [20] pointed out that to ensure value chain competitiveness in the long term, DSCs should consider sustainability [24]. In this context, Blockchain plays a very significant role in SC sustainability development because it can transform sustainability management [11]. For this reason, with increasing sustainability concerns, organizations are implementing BCT to solve a variety of environmental supply chain issues using decentralized and unchangeable, and accurate data, traceability, transparency, and smart contracts [23]. The Blockchain helps to minimize data fluctuations that may undermine financially and socially SCs [11]. Indeed, reducing illegal practices also enables BT to enhance the social dimension of the sustainable supply chain [25]. Besides, Blockchain maintains a comprehensive track of the supply chain flows that help organizations strengthen trust in product sustainability authenticity [5] and minimize product recall and rework [17]. It can also calculate the organizations' carbon tax price due to the real-time traceability of goods footprint. Moreover, it can identify social and environmental issues that could threaten environmental concerns. According to [23], the reliability, security, and transparency BT characteristics add socio-environmental sustainability value to SCs flows. With these properties, blockchain technology might be the most promising technology for sustainable supply chain management [9].

#### **BT for agile digital supply chain**

According to [26], agility is known as the ability to instantly identify and exploit competitive opportunities. That is, agility is about bringing improvement in an appropriate, flexible and adaptive way to follow changing market trends. For this reason, particularly with the COVID-19 pandemic, there is a need for having more agile SCs [27]. In this context, adopting BT can help supply chain agility. It not only increases responsiveness and performance but also increases supply chain authenticity, visibility, and traceability. Besides, it assists the End-to-end actors in sharing, communicating, collaborating, and compromising as well as increasing productivity [27]. Besides, using transparent BT, in production planning and inventory management, provides transparent and accurate information that makes production technologies more agile [20]. Thus, it improves supply chain agility, especially when used with different industry 4.0 technologies.

### **3.3 Blockchain technology adoption barriers in viable digital supply chain**

Over the years, the relevance of introducing BT has been increasing. Organizations are engaging in BT projects to achieve high performance. However, unfortunately,

many barriers and challenges discourage its implementation. Appropriate identification of the relevant barriers that impacted BT's adoption in the VDSC helps to ensure its successful implementation [28, 29]. The identification of BT barriers is based on a literature review, which is a crucial step in collecting pertinent research articles on the subject. It is also about producing an extensive list of barriers that challenge the BT adoption in organizations. Those barriers are classified into five groups: inter-organizational barriers, intra-organizational barriers, industry 4.0 technology barriers, external barriers, and social and environmental barriers. As it is not possible to evaluate all the barriers in this research. An initial list of the BT barriers in VDSC was collected from a literature review (see Table 1).

**Table 1.** Barriers in implementing Blockchain technology in VDSC

<b>Barriers</b>	<b>Sub-barriers</b>	<b>References</b>
Inter-organizational barriers	Lack of awareness	[4, 13, 21]
	Collaboration and network establishment issues	
	Lack of technical expertise	
	Issues with transparency and disclosure of “critical” data	
Intra-organizational barriers	Lack of trust	[4, 13, 30, 30]
	Lack of management support	
	Missing infrastructure	
	Financial constraints	
Industry 4.0 Technology barriers	Immaturity of technology	[4, 13, 30, 30]
	Lack of standardization	
	Complex protocol selection	
	Limited knowledge of the complex technology	
	Security and technical vulnerability	
External barriers	Interoperability	[4, 13, 21, 30]
	Legal uncertainties (smart contracts)	
	Market competition	
Social and environmental barriers	Speed of technological development	[8, 11]
	Information sharing (environmental and social aspects)	
	Wasted resources	
	Lack of awareness and tendency about sustainability	

From the literature review, it was found that there is a lack of studies on BT adoption barriers for VDSC. Besides, as far as we know, no study has addressed the BT barriers adoption considering digitalization, resilience and sustainability capabilities using DEMATEL. Lastly, especially with the increase of disruptions that SCs face, it is essential to comprehend barriers from the point of view of cause and effect. Since only determining their dependency or driving power or ranking them is not enough. For this reason, the purpose of this paper is to evaluate the BT adoption barriers by determining the cause/effect interrelation.



#### 4 DEMATEL for Blockchain technology adoption barriers in viable digital supply chain

DEMATEL is a structuring method used to analyze and identify the cause and effect interaction between the studied factors [31]. This approach aims to incorporate a di-graph and a cause and effect connection diagram. In other words, the diagram and the cause and effect connection diagram illustrate the results of each aspect on the other [31]. DEMATEL has several benefits across AHP and ISM [32]. Using the AHP approach considers the criteria as independent of each other, which is not practical in realistic scenarios. ISM approach determines relationships between variables based on their dependency and driving power but does not identify the significance of their effects. Therefore, DEMATEL has an advantage over these Multi-Criteria Decision-Making Methods approaches since it indicates the factors relationship and ranks them according to their importance and the nature of their impact on each other.

The first step to be taken is data collection to assess the prominence and cause/effect relationship between the BT adoption barriers. As the DEMATEL technique is built on expert insights, a cross-functional team of 4 academic experts and 6 practitioners is formed. The experts team has a role to discuss the identified barriers and to establish the relationship between them. Besides, three online-meeting were arranged with experts. In the first one, the initial 20 identified barriers were discussed. Based on their response, we have selected the 12 most relevant barriers to BT's adoption for VDSC. In the second meeting, the expert's team was asked to determine each barrier's influence on the other. And the final meeting was arranged for discussing and validating the findings.

After selecting the comprehensive list of BT barriers to be evaluated, we begin calculus according the DEMATEL following steps:

The first step consists of generating a pair-wise comparison matrix based on the following scale:

- 0 if there is no influence;
- 1 if there is very low influence;
- 2 if there is low influence;
- 3 if there is medium influence;
- 4 if there is high influence;
- 5 if there is very high influence.

$$A_k = \begin{bmatrix} 0 & a_{12k} & a_{13k} & \dots & a_{1nk} & a_{1nk} \\ a_{21k} & 0 & a_{23k} & \dots & 0 & a_{2nk} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ a_{(n-1)1k} & a_{(n-1)2k} & a_{(n-1)3k} & \dots & 0 & a_{(n-1)nk} \\ a_{n1k} & a_{n2k} & a_{n3k} & \dots & a_{n(n-1)k} & 0 \end{bmatrix} \quad (1)$$

This matrix  $A_K = [a_{ijk}]_n$  (equation 1) represents the influence of barrier  $i$  over  $j$  where  $n$  is the number of barriers and  $k$  is the number of experts. Besides, its diagonal has a value of 0 because barriers don't influence themselves. Then, we obtain the overall direct relationship matrix  $A$  (table 2) using (equation 2) where  $a_{ij}$  is the average of  $a_{ijk}$  of all experts.

$$A = \frac{[a_{ij}]}{k} \quad (2)$$

**Table 2.** Average scores for barriers interaction

Barriers	B 1	B 2	B 3	B 4	B 5	B 6	B 7	B 8	B 9	B 10	B 11	B1 2	Sum
Lack of awareness	B 1	0	1, 3, 4 2	0, 0, 6 4	2, 2, 4 2	1, 2, 2 2	1, 2, 2 2	1, 2, 2 2	1, 2, 2 2	1, 2, 2 2	3, 3, 6 4	1	18,8
Data transparency	B 2	1, 4	0, 4	3, 4	0, 4	2, 6	3, 3	1, 6	1, 2	0, 8	3, 3, 8 4	0,4	23,2
Lack of trust	B 3	1, 6	0, 0	1, 1, 2 4	1, 1, 6 4	1, 1, 6 4	1, 1, 6 4	2, 2, 8 2	0, 0, 8 2	3, 3, 8 2	0, 0, 2 2	0,4	14,6
Financial constraints	B 4	0, 1	1, 0	0, 0	3, 3, 6 4	3, 3, 6 4	0, 0	2, 2, 6 4	4, 4	1, 1, 8 8	3, 3, 8 8	3,2	22,6
Immaturity of technology	B 5	2, 8	3, 4	3, 2	1, 6	1, 0	3, 2, 2 8	2, 2, 8 8	1, 1, 8 8	2, 2, 8 8	3, 3, 2 2	2,2	29
Lack of standardization	B 6	2, 2	2, 8	3, 6	2, 2	2, 8	0, 0	3, 2, 2 8	1, 1, 6 6	2, 2, 2 2	3, 3, 2 2	1,8	29,4
Security and technical vulnerability	B 7	2, 2	4, 4	4, 4	1, 2, 2 8	2, 2, 8 2	3, 3, 0 0	0, 0, 2 4	3, 3, 6 6	2, 2, 6 6	3, 3, 6 6	1,4	31,6
Legal uncertainties	B 8	1, 2	1, 6	3, 2	2, 2	1, 2, 2 8	2, 2, 8 8	0, 0, 0 0	0, 0, 2 2	2, 2, 8 8	1, 1, 4 4	2,2	18,6
Missing infrastructure	B 9	1, 4	3, 4	2, 4	2, 8	3, 8	3, 6	3, 4	0, 6	0, 6	3, 1, 6 8	1,4	27,8
Information sharing	B 10	3, 2	3, 6	3, 4	1, 8	0, 6	2, 2, 4 6	1, 1, 6 6	1, 1, 6 6	0, 0, 6 6	2, 2, 8 8	3,4	24,6
Wasted resources	B 11	1, 8	3, 2	3, 6	2, 8	2, 8	2, 8	3, 2	1, 4	3, 3, 6 2	0, 0	3,6	31,2
High Sustainability Costs	B 12	0, 0	0, 0	4, 4	1, 2	1, 2	0, 0	1, 2, 4 8	2, 2, 4 8	3, 3, 4 4	0, 0	0	15,2

The second step consists of normalizing the obtained overall direct relation matrix  $A$ . Thus, the normalized overall direct-relation matrix  $N$  is obtained using (equation 3).

$$N = [b_{ij}]_{n \times n} = \frac{A}{\max_{1 \leq i \leq n} \sum_{j=1}^n a_{ij}} \text{ where } 0 \leq b_{ij} \leq 1 \quad (3)$$

The third step consists of calculating the total relation matrix ( $T$ ). We obtained total relation matrix ( $T$ ) (table 3) by using (equation 4) where  $I$  refers to the identity matrix.

$$T = [t_{ij}]_{n \times n} = N[I - T]^{-1} \quad (4)$$

**Table 3.** Total relation matrix

	<b>B1</b>	<b>B2</b>	<b>B3</b>	<b>B4</b>	<b>B5</b>	<b>B6</b>	<b>B7</b>	<b>B8</b>	<b>B9</b>	<b>B10</b>	<b>B11</b>	<b>B12</b>
B1	0,11	0,20	0,29	0,15	0,16	0,24	0,17	0,20	0,14	0,29	0,25	0,17
	8	7	2	3	0	8	8	7	9	6	2	2
B2	0,20	0,22	0,36	0,18	0,26	0,32	0,29	0,22	0,15	0,39	0,31	0,19
	2	0	1	1	5	5	1	4	7	1	9	6
B3	0,14	0,13	0,15	0,13	0,15	0,19	0,14	0,19	0,09	0,27	0,14	0,12
	4	1	5	9	1	0	6	5	7	6	0	6
B4	0,14	0,24	0,24	0,18	0,30	0,33	0,18	0,25	0,28	0,32	0,30	0,27
	8	6	6	0	1	9	7	1	0	8	0	8
B5	0,26	0,35	0,39	0,25	0,22	0,37	0,30	0,30	0,29	0,39	0,35	0,27
	2	1	6	1	8	8	1	1	3	5	1	8
B6	0,25	0,34	0,41	0,27	0,31	0,29	0,31	0,27	0,26	0,43	0,35	0,27
	1	4	4	3	7	4	8	9	7	6	8	4
B7	0,26	0,39	0,44	0,25	0,32	0,40	0,24	0,33	0,26	0,46	0,38	0,27
	4	3	8	6	8	2	1	0	7	9	5	5
B8	0,14	0,20	0,27	0,18	0,17	0,24	0,15	0,13	0,11	0,28	0,20	0,20
	8	0	7	8	5	0	5	8	8	9	0	1
B9	0,21	0,36	0,37	0,28	0,34	0,39	0,32	0,24	0,19	0,43	0,32	0,25
	7	0	6	5	4	4	2	1	0	8	1	9
B10	0,23	0,30	0,34	0,22	0,20	0,29	0,21	0,22	0,17	0,27	0,28	0,27
	6	3	0	1	3	5	6	6	1	5	9	2
B11	0,22	0,38	0,41	0,30	0,33	0,39	0,33	0,27	0,30	0,45	0,28	0,33
	5	5	5	0	4	4	0	8	8	6	0	6
B12	0,09	0,14	0,16	0,23	0,16	0,22	0,11	0,16	0,19	0,27	0,15	0,12
	2	9	4	0	7	9	1	8	0	4	9	8

The fourth step consists of determining the row and column sums from the total relation matrix (T). The sum of column and the sum of rows are denoted C and R (see table 4). The fifth step consists of determining the net effect and overall prominence values (table 4).

**Table 4.** Direct-indirect matrix

<b>Barriers</b>	<b>R</b>	<b>C</b>	<b>C+R</b>	<b>Rank</b>	<b>R-C</b>	<b>Cause/effect</b>
B1	2,432	2,314	4,75	12	0,12	Cause
B2	3,132	3,284	6,42	6	-0,15	Effect
B3	1,89	3,88	5,77	8	-1,99	Effect
B4	3,084	2,664	5,75	9	0,42	Cause
B5	3,785	2,975	6,76	5	0,81	Cause
B6	3,825	3,72	7,55	1	0,1	Cause
B7	4,058	2,803	6,86	4	1,26	Cause
B8	2,329	2,83	5,16	10	-0,5	Effect
B9	3,747	2,491	6,24	7	1,26	Cause

B10	3,047	4,328	7,38	3	-1,28	Effect
B11	4,041	3,354	7,4	2	0,69	Cause
B12	2,068	2,795	4,86	11	-0,73	Effect

DEMATEL is one of the key instruments that have to be well presented to be effectively interpreted. For this reason, we established a causal diagram based on the previous analysis. After determining the overall prominence and net effect values, a causal diagram is drawn by placing  $(R_{ij} + C_{ij}, R_{ij} - C_{ij})$  values and then drawing a directed graph to understand the BT adoption barriers' interrelationship. The causal diagram is presented in (Fig.2).

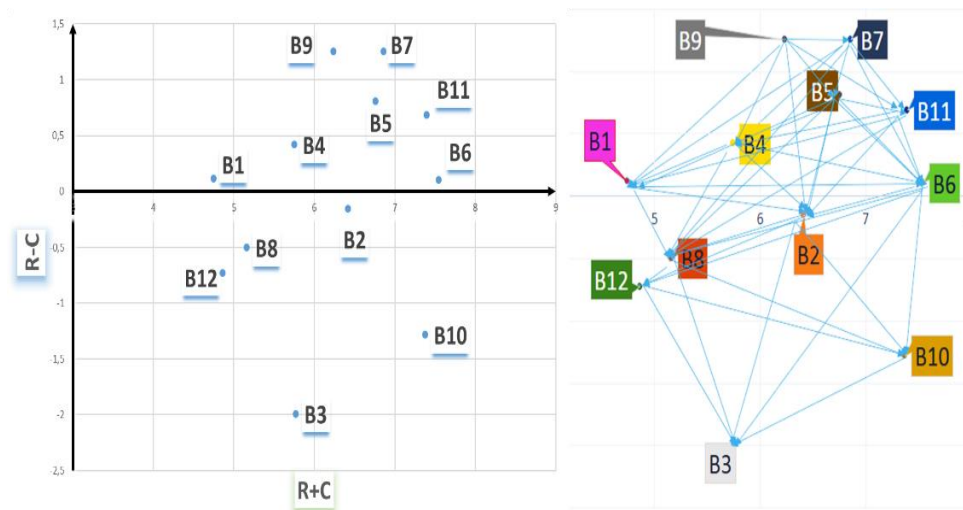


Fig. 2. Prominence-Causal Diagrams

## 5 Analysis and Discussion of Results

Based on the previous section and as the objective is to examine the interconnections between the identified barriers for the BT adoption in the VDSC, we analyze three barriers categories (influential, prominent and the resulting). Influencing barriers have a higher net effect value (R-C). Hence, the five most significant influencing barriers that have a crucial impact on the adoption of BT in VDSC are “Missing infrastructure (B9)”, “Security and technical vulnerability (B7)”, “Immaturity and interoperability of technology (B5)”, “Wasted resources (B11)” and “Financial constraints (B4)”. Adopting BT may be a specific issue in DSCs if the infrastructure is missing or not properly set, as it is the most influential barrier outlined in this study. These B9, B7, B5, B11 are linked to technological advancement and security concerns. In fact, according to [4] BT’ technical vulnerability and security limits further diffusion. Thus, managers should invest in infrastructure to sustain technological assets to avoid failures in BT’s implementation. Besides, research on governance models needs to intensify.

Prominent barriers (causal barriers) have a high prominence score, reflecting the strong connection with other barriers and having a considerable effect on other ones. Thus, stakeholders must recognize and address these barriers to ensure the effective adoption of BT within their VDSCs [33]. As we can observe, "Lack of standardization (B6)", "Wasted resources (B11)", "Information sharing (B10)" and "Security and technical vulnerability (B7)" are the most significant elements barring the effective implementation of BT in the VDSC. According to [34] lack of standardization is a critical barrier since it leads to technological uncertainty. Besides, [4] argues that Blockchain standards, specifying how transactions are structured, secured and validated in the networks, should be established. Hence, organizations structures are necessary for decentralizing the networks and allow end-to-end transparency to ensure a standards application [4]. Thus, Managers should carefully prepare to monitor business strategies, resolve the primary causes of the barriers and engage in resources investment that will help implement BT in VDSC. Stakeholders should rely on concrete strategies to better achieve the opportunities of BT.

The resulting barriers are the most affected ones. Hence, organizations need to think about these barriers after assessing other ones. The resulting barriers, with a negative net effect value are "Lack of trust (B3)", "Information sharing (B10)", "High sustainability cost (B12)", "Legal uncertainties (B8)", and "data transparency (B2)". As seen in Fig 2, several barriers have a significant impact on the resulting factors. For instance, multiple arrows point to "Lack of trust". Also, data transparency is still perceived as a significant risk by industries. In other words, according to [35], data transparency could be a blocking point while sharing sensitive information in real-time.

To sum up, organizations need to adopt plans and roadmaps to address various causes, and the resultant elements can be considered only after the primary influencing barriers have been addressed. Thus, it is crucial to begin by mitigating the most significant barriers then tackling the resulting one.

## **6 Implications**

The findings discussed in this paper enable many research contributions. They offer implications for practices and researchers. They discussed barriers that may be considered a reference for stakeholders since this research addresses the most crucial barriers to BT's adoption in VDSCs. In other words, the results will assist in selecting the most relevant barriers, the least critical barriers, and how the barriers interact with one another. Besides, it will help stakeholders increase their awareness of the barriers and prioritize the barriers to be addressed. Thus, organizations must develop effective practices and strategies to ensure the effective adoption of BT in DSCs. Our findings indicate that managers should worry about improving the technology barriers to addressing BT's adoption barriers. It is important to note that technology barriers are a crucial concern independently of the organization's structure. To improve technological capability, managers should emphasize developing roadmaps and short and long-term strategies to benefit from the BT opportunities. More clearly, managers should identify

the blockchain functionalities interoperable with other technologies and examine potential use cases.

Furthermore, researchers from other manufacturing and industry areas can use the suggested approach and analyses on the derived results. The findings remind executives that to increase and improve the effectiveness of blockchain implementation, they must employ members in their supply chains so that BT's benefits can be put to meaningful. Moreover, under developing and developing countries should plan to enhance policies to support BT implementation. Some limitations and questions raised by this research give multiple study pathways. For instance, our research is based on a particular number of experts.

## 7 Conclusion

Blockchain is a potential technology having numerous advantages like encryption, transparency, cost-saving, and traceability transforming many industries [3]. However, implementing BTs in DSCs is still in its infancy and is surrounded by several barriers that limit its adoption. Consequently, this paper aims to evaluate and examine the BT adoption barriers in VDSC. More clearly, it presents a causality diagram that illustrates the cause/effect relationship between the identified barriers. Also, it analyzes and discusses the findings to present implications for practitioners and managers.

Barriers that may impact the adoption of BT present real challenges for technical experts and managers. However, 12 barriers have been identified in this analysis and are evaluated in terms of cause/effect interaction using DEMATEL. Analysis results have shown that "Lack of trust (B3)", "Information sharing (B10)", "High sustainability cost (B12)", "Legal uncertainties (B8)", and "data transparency (B2)" are known as a resulting barrier, while "Missing infrastructure (B9)", "Security and technical vulnerability (B7)", "Immaturity and interoperability of technology (B5)", "Wasted resources (B11)" and "Financial constraints (B4)" were categorized as influencing barriers. Thus, the "Lack of standardization (B6)", "Wasted resources (B11)", "Information sharing (B10)" and "Security and technical vulnerability (B7)" are prominent barriers and have an impact on many other barriers. Therefore, these barriers should be prioritized in order to have a successful adoption of BT in VDSC.

This paper has certain limitations that present improvement potential for future research. First, this work studied 12 barriers that impact BT adoption only. More barriers have not been identified and have not been studied. Second, the initial matrix retrieved from the experts' team has a probable uncertainty over specific interactions. This uncertainty can be overcome by incorporating gray and fuzzy set theories. Finally, this work has not studied the disruptions caused by Covid-19 impact on BT adoption. Thus, future research can explore how covid-19 epidemics affect the implementation of BT in VDSC.

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