logistics

Article

Integration of Blockchain Technology and Prioritization of Deployment Barriers in the Blood Supply Chain

Ieva Meidute-Kavaliauskiene [1,*], Amir Karbassi Yazdi [2] and Amir Mehdiabadi [2]

1 Department of Business Technologies and Entrepreneurship, Business Management Faculty, Vilnius Gediminas Technical University, Saulėtekio al. 11, 10223 Vilnius, Lithuania
2 Industrial Management Department, Islamic Azad University, Tehran 1477893855, Iran; st_a_karbassiyazdi@azad.ac.ir (A.K.Y.); amir.mehdiabadi@gmail.com (A.M.)
* Correspondence: ieva.meidute-kavaliauskiene@vilniustech.lt

Abstract: *Background:* This research aims to prioritize the blood supply hub for coping barriers of implementation blockchain (BC) in supply chain management (SCM). Nowadays, blood supply is a crucial matter that plays an essential role in people's lives. Hence, tracing the supply of blood is very substantial. One of the ways for the SCM of blood supply is a blockchain system. It shows how all traces of the SCM stream can flow from raw material to receiving blood into end users. However, there are many barriers to the implementation of blockchain. None of the companies can design improvement projects to resolve these barriers because of a lack of rare resources, such as human resources (HR), budget, information, etc. *Methods:* Barriers are first extracted from previous studies and interviews with experts in this study. Then, these barriers are customized for this case study by the Delphi method. Then, these blood supply hubs are ranked by measurement alternatives and ranking according to the compromise solution (MARCOS) method. Since this method needs primary weight, the best–worst method (BWM) is applied to obtain this weight. *Result*: Results have pointed out that business owners' unwillingness was the highest priority among the nine barriers. *Conclusions:* Additionally, implementing blockchain for SCM of blood supply requires paying more attention to business owners' unwillingness barriers and resolving them. Furthermore, hub 4 is faced with many problems in tackling barriers to implementing SCM blockchain.

Keywords: blood supply hub; supply chain management; blockchain; MARCOS method; best–worst method

check for updates

Citation: Meidute-Kavaliauskiene, I.; Yazdi, A.K.; Mehdiabadi, A. Integration of Blockchain Technology and Prioritization of Deployment Barriers in the Blood Supply Chain. *Logistics* **2022**, *6*, 21. https://doi.org/10.3390/logistics6010021

Academic Editor: Robert Handfield

Received: 5 January 2022
Accepted: 25 February 2022
Published: 4 March 2022

1. Introduction

Using supply chain management (SCM) aims to change raw materials to final goods and services by processing raw materials [1]. SCM helps companies decrease operation costs, accelerate the process, and ultimately increase customer satisfaction [2]. Many factors must be considered during the SCM, such as inventories, lead time (LT), time of the process, etc. [3]. These factors have a substantial effect on all aspects of companies. Hence, the SCM and implementation of it are essential. The first use of blockchain (BC) dates back to the cryptocurrency market and the invention of bitcoin [4]. This new invention had a strong effect on all businesses of the world. Blockchain technology has many applications in health and medical data security [5]. This technology will provide patients with a comprehensive, unchanging report with easy access to medical information across health networks and treatment sites. In recent years, rising health care costs have put a strain on the global economy. Therefore, regulatory agencies have identified the ability to share and cooperate with drug tracking and data security as the most critical issues in the health care industry [6]. According to a global study by IBM in 2017, a large company's data breach cost averaged USD 3.62 million. Harvard Medical School recently released a report showing that about USD 445 billion is lost annually in health care due to fraud. In 2015 alone, more than USD 700 million was embezzled in the United States. For this reason, the industry desperately needs a system with a capability to verify the accuracy of work. The Chinese blockchain technology can meet this need, so it is indispensable to implement a Chinese blockchain-based system in the global health industry.

Blockchain in medicine acts as a verification tool to ensure that only authorized users, such as physicians, insurance providers, or patients, make changes. Blockchain interoperability can be the basis of data exchange and serve as an alternative to today's health information interchange (HIE) [7,8]. The network acts as a network for instantaneous and immediate transmission of patient information to health care providers, pharmacies, insurers, and clinical researchers. Patients' records are stored securely and provided to medical centers when needed with this technology. In 2017, the startup MintHealth launched portable personal health records based on the Chinese blockchain. These programs are used to help patients with chronic diseases, such as heart failure, diabetes, and high blood pressure. Today, these patients account for an average of more than 90% of health care costs. Amazon is a natural language processing engine that can read physicians' prescriptions in radiology, and this service uses machine-learning algorithms. In early 2019, SAP launched a blockchain-based supply chain tracking service. This service enables drug wholesalers to authenticate the packaging of medicines returned from hospitals and pharmacies. The center plans to expand this technology to cover a wide range of drug supply chain processes. Medical care companies, technology innovators, and other industry sectors are grappling with two questions: (1) What is currently operational?; (2) What problems can blockchain solve in the future? Blockchain's overall vision is to make a difference in the medical care industry in the future [9].

The SCM is not exempted from this revolution. After some time, many companies have applied BC in SCM. Blockchain helps companies trace all raw materials from the seller to deliver final goods and services to end users [10]. Many blood supply chain performance improvements can dramatically improve health systems' efficiency and cost savings. Since health systems, especially in developing countries, such as Iran, face the problem of increased costs, and a large part of health systems' costs are directed to the blood supply chain, any improvement in this chain's efficiency and performance will reduce costs.

Furthermore, companies can pay the seller to buy raw materials and receive money from end users or retails. Thanks to this method, companies can engage in good transactions, and hence the circulation of money in companies is fast and effective [11]. Moreover, by tracing all batches, companies, especially managers, can decide to buy raw materials, maintaining inventories and sales figures, and consequently, production costs decrease dramatically [12]. Supply blood in all cities, especially large towns, is a substantial issue for many reasons. Blood supply is essential for people involved in car or bicycle accidents. Since the populations in these cities are very high, and there are many cars and bikes on highways, streets, and so on, the probability of accident events is very high.

Furthermore, many pregnant women need blood when they give birth to newborns. Without the correct supply chain blood, many lives will be in danger. This research aims to prioritize the barriers to implementing SCM blockchain for supplying blood to hospitals in emergencies. Hence, in this paper, first barriers to implementing BC for blood supply are extracted. Then, since the implementation of this technology requires the allocation of limited resources, such as human resources (HR), budget, time, information, and other resources, these barriers must be prioritized. For prioritizing, multi-criteria decision-making) MCDM(techniques are applied in an uncertain environment. The novelty of this paper is using hybrid MCDM methods for prioritizing hubs of blood supply according to barriers to implementation of supply chain management BC for hospitals in large cities. Although they have published some papers about the combination of best–worst method (BWM), measurement alternatives, and ranking, according to the Compromise Solution (MARCOS), in both certain and uncertain environments, there is no evidence that researchers applied these hybrid methods to prioritize BC barriers for SCM of blood supply.

- Question 1—What are the barriers to implementing BC for supply blood?
- Question 2—Which barrier has a high priority for implementing BC for blood supply?
- Question 3—Which hub must focus on that to eliminate SCM BC barriers?

This paper consists of five sections. After the introduction section, the literature review section is demonstrated in section two. Section three deals the research methodology section. After section three, the data analysis section as the fourth section is displayed. The final section reveals the conclusion.

2. Literature Review

The concept of supply chain management was introduced in the early 1990s [13]. This structure seeks to manage a value creation chain, from the original producer to the final customer. According to Ivanov, the supply chain is a network with the ability to cooperate and coordinate among the value chain members to supply raw materials, convert materials into final products, and transfer products prepared to customers [14]. Supply chain design and implementation are conducted at different levels. At the upper level, the goal is to organize the proper communication of the chain, and at the lower level, the goal is to create and execute operational processes [15]. Performance management and evaluation indicators can also be classified into three levels: strategic, tactical, and operational [16]. One of the most critical issues in supply chain management is decision alignment. The supply chain has a multilevel and related structure that means optimization in one part will not necessarily lead to the optimal performance of the whole chain [17,18].

A blockchain network contains records of data that are stored in blocks at various points in the network [19]. Each block depends on a timestamp. The accuracy of the timestamp is guaranteed based on a convergence protocol between the participating parties and the encryption algorithm in the hash [20]. Blockchain technology, as a potentially disruptive technology with the characteristics of an unreliable decentralized database, enables global-scale transactions, intermediation and decentralization between different parties [21]. Blockchain is an open-source technology, and no one owns it [13]. This technology does not have a central ruler to approve transactions and operates self-regulating [22]. The technology is an encrypted digital general ledger that stores transaction data in a decentralized public ledger. These blocks are added to each other to create an endless chain when this chain is shared among all participants. Such an architecture has advantages such as improving traceability and increasing trust in a chain [23]. Blockchain reduces third-party reliance on peer-to-peer networks. This technology makes the information immutably available to all participants to reduce fraud.

Today, customers want everything together. Managerial interpretation of this need means trusting, being responsive, reducing prices, increasing quality and other customer interests [24]. The concept of supply chain management simultaneously seeks to reduce costs and increase customer satisfaction [19]. Due to the vast supply chain of today's organizations, traditional supply chain procedures and processes are no longer effective, and managers have turned to new methods and technologies to improve supply chain performance. With the development of communication and information technology in industry and services, the rate of detecting, recording and updating information has increased and, consequently, the power of control and decision-making has improved [25]. Utilizing a new approach has increased the speed of recognizing changes and making recent optimal decisions [19]. With this possibility, the power of adapting decisions to the facts will increase, and we will have more agile chains. The continuous detection of changes and appropriate responses is a good approach for continuous improvement. New blockchain technology is one of the most recently considered technologies due to its key features, such as its prevention of forgery, decentralization and transparency [26]. The essence of modern supply chains is complex and has a multi-tiered existence to serve consumers [27–29]. In addition, globalization policies have made diversity, cultures, information evaluation and risk management in the supply chain an unpredictable and complex phenomenon [30]. Blockchain is a network-based distributed mass storage structure [31]. Recently, various fields of science have been trying to use this technology.

Currency cryptocurrencies, supply chains, scientific data storage centers, public health and intelligent cities are applications of this emerging technology [32]. Blockchain can increase the ability to track information and security in the supply chain by securing the collection, transfer and sharing of valid data at each production stage, processing, warehousing, distribution and sale [33]. The ability to detect, record, and transmit information based on radio frequency identification (RFID) and the Internet of Things, along with improving blockchain-based reliability, can increase the reliability of the knowledge gained from information storage and improve the authority to use it [29]. The two most important features of the China blockchain are its distribution and aftermath. In this context, the parties to the chain agree in detail on the details of the chain [34]. One of the most significant achievements of using blockchain is ensuring that the data are not manipulated and the information is accurate, which guarantees the availability of reliable knowledge [35]. In general, some of the problems that exist during the supply and delivery chain from the time of production to the time of delivery to the consumer and cause a waste of time and capital are:

1. Impossibility of viewing and monitoring assets from the beginning to the end of the chain: Which goods are at which point at any given moment.
2. Identification/tracking of goods: lack of proper answers to questions—Who? When? Where? Why?
3. Security and fraud issues: the possibility of entering fake and invalid data in the chain and uncertainty in answering whether this is my product?
4. Verification of events in the chain: Have the goods been shipped? Has it reached its destination?

Blockchain technology will provide more efficient and secure tools in this area. The unchanging nature of this technology can bring about dramatic changes for the health care sector, and for this reason, it seems perfectly appropriate for this sector. Shahnaz et al. [36] studied blockchain technology in Electronic Health Records. In addition to implementing this technology, researchers in this study provide secure storage of electronic records by denying granular access rules for users of the proposed framework. Human blood is a scarce resource that is produced only by humans themselves, and there is currently no other chemical product or process that can replace it. Providing healthy and adequate blood for hospitals and managing it under normal circumstances is a critical challenge that governments' health systems always face. There will always be a need for blood donors and their products; matching supply and demand efficiently for this product is not easy. Blood and blood products are perishable products that make this more difficult. Blood deficiency brings a high costs to society because it increases the mortality rate. Sadaphule et al. [37] reviewed the health supply chain and blockchain technology. They sought to identify the problems facing health care workers and provide a model.

Research has also been conducted systematically and reviewed in this area [38–40]. Hölbl et al. [39] employed bibliometric techniques to present an overview of blockchain elements and research trends about blockchain application in healthcare. Angraal et al. [41] detailed the various platforms developed to deploy blockchain in healthcare. Agbo et al. [42] discussed different instances of adopting blockchain technology in healthcare, the challenges faced, and possible solutions. O'Donoghue et al. [39] discussed specific trade-offs and design choices executed by researchers in various scenarios where blockchain technology was applied. Jaoude and Saade [43] curated studies about blockchain applications across multiple industries and broadly discussed the different usage contexts for this technology. Recently, Hasselgren et al. [44] analyzed 39 studies to present summary statistics on popular platforms and targeted areas wherein blockchain has been applied to improve Healthcare.

Mathivathanan et al. [45], in their research regarding the Total Interpretive Structural Modelling (TISM) approach, concluded that the lack of business awareness and familiarity with blockchain technology on what it can deliver for future supply chains are the most significant barriers that impede blockchain adoption. These barriers hinder and impact businesses decisions to establish a blockchain-enabled supply chain and those other barriers act as secondary and linked variables in the adoption process. Ozdemir et al., in their research regarding the intuitionistic fuzzy analytic network process, concluded that inter-organizational barriers are the most suitable ones, the impacts of which blockchain may alleviate [46]. This study further suggests that trust turned out to be the most significant benefit criterion for the analysis. Biswas and Gupta [47] analysis of barriers to implementing blockchain in industry and service sectors suggests that adopting and implementing blockchain technologies in various industries and services is challenging. They provide a tenth classification of these barriers, including challenges in scalability, market-based risks, transaction-level uncertainties, technology risks, high sustainability costs, poor economic behavior in the long run, privacy risks, usages in the underground economy, risks of cyber-attacks and legal and regulatory uncertainties. Therefore, in Table 1, the following barriers have been identified and suggested the application of blockchain technology in the supply chain by researchers:

Table 1. Barriers to the application of blockchain technology in the supply chain.

Barrier and Description	Reference
Business Owner's unwillingness: Fear of change, investment, organization culture	[45,47]
Unfamiliarity with Technology: Lack of awareness, the infancy of the technology	[48,49]
Data privacy/security Concerns: Cyber security concerns, possible illegal surveillance, and possible fear of data misuse	[49,50]
Technological infeasibility: Lack of enormous computing power, level of technical maturity is not the same along with the supply chain partners	[41,42,51]
Complexity in set up/use: Massive financial investment, common software platform required, initiators commitment	[12,48,52,53]
Uncertain benefits: Uncertain benefits are key practical challenges	[54,55]
Dependence on Blockchain operators: Trade-offs in the initial setup, fear of reliance on blockchain operators	[56,57]
Lack of Cooperation among SC partners: Supply chain partners must have the same level of technological maturity	[58,59]
Risks of cyber-attacks: Network-based attacks, Selfish mining attacks	[60,61]
Privacy Risks: Anonymity, Data Privacy with personal records	[32,62]
Market-based Risks: Price volatility and fluctuating exchange rate, Questionable hype, Risk of future adoption by merchants	[41,63]

Yadav and Singh [64] show the critical role of some of the causes that lead to the integration of blockchain with the supply chain and, ultimately, stability. Data security and decentralization, accessibility, rules and policies, documentation, data management and quality are some things that help block strategy development. Behnke and Janssen [65] concluded that blockchain is valuable because it leads to more data sharing among supply chain members. However, boundary conditions must be met before using blockchain technology. It indicates that the supply chain must be organized before using blockchain. Rawat et al. [20] conducted a study to explain the implementation of blockchain technology in the production chain delivery system and the egg's width from the farm to the consumer. They consider the entry of blockchain in the food supply chain as the beginning of a revolution that allows tracking food chains accurately.

The implementation of blockchain in SCM is an emerging subject in this term. Hence, a few types of research have been published about that. However, publishing research focusing on the barriers to implementing blockchain is scarce. Ultimately, there is no evidence of publishing a paper about prioritizing implementation of BC in SCM of supply blood. Since supply blood is essential to work that directly relates to the death or life of people, many papers have been published about diverse issues of blood supply and related methods. Still, none of them focus on using BC and barriers to implementation of BC. The research gap of this research is the introduction of the new term SCM blood supply and how BC works in the face of it.

3. Methods

This research aims to apply a combination of multi-criteria decision-making methods for analysis. Eight experts were selected to answer all the questions of this study. The methods are described below.

The Delphi method has been applied to customizing barriers to implementation of BC in SCM supply blood in this paper. This method screening barrier. The primary purpose of the Delphi technique is to reach a consensus of a group of experts. Management researchers specifically use this technique to validate decision-making indicators. Therefore, although this method is not a multi-criteria decision-making method, in many cases, before using multi-criteria decision-making techniques, this technique is used to screen the indicators or reach an agreement on the importance of decision-making indicators [58]. The steps of this method are first a questionnaire based on barriers, and five scales Likert has designed (from very low = 1 to very high = 5). Afterwards, this questionnaire distributes among expert people. This study has selected experts from the most specialized physicians in the hematology department. There is a disputing about the number of decision makers (DMs) in this method. Some scientists believe that this number must be more than 100 people, but others pointed out it must be five to fifteen [66]. After gathering questionnaires, they will be analyzed. If the average of the scores is more than four, this "barrier" is accepted; otherwise, it will be rejected.

BWM method is one of the most popular methods in the world. This method belongs to one of the MCDM methods that allocate weights to alternatives or criteria. It eliminates some drawbacks of the traditional Analytical Hierarchy Process (AHP) method, such as less comparison and high accuracy. Rezaei [67] introduced this method, which has been applied in many papers [68,69]. For the implementation of that, these steps must be done:

Step 1. Looking forward to setting the criteria and alternatives of the model. $C = \{c_1, c_2, \ldots, c_n\}$ represents criteria of problem.

Step 2. The worst and best criteria of the problem are identified.

Step 3. The best criterion is shown (denoted as B), and afterwards, it compares with the rest of the criteria according to 1–9 scale. For showing the best preferences of the best criterion B are indicated as $A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn})$. It is obvious that $a_{BB} = 1$.

Step 4. The worst criterion is shown (denoted as W), and afterwards, it compares with the rest of the criteria according to 1–9 scale. For displaying the worst preferences of the best criterion W are indicated as $A_w = (a_{w1}, a_{w2}, \ldots, a_{wn})$. It is obvious that $a_{ww} = 1$.

Step 5. Final weights are shown due to the following formula. These weights are $(w_1^*, w_2^*, \ldots, w_n^*)$.

The maximum absolute differences $\left|\frac{w_B}{w_j} - a_{Bj}\right|$ and $\left|\frac{w_j}{w_w} - a_{wj}\right|$ are minimized for all j, such as the ratio of weights related to best relative preferences. n represents the number of iterations, and j is a number of criteria. The equation below shows this computation.

$$\min \max_j \left\{ \left|\frac{w_B}{w_j} - a_{Bj}\right|, \left|\frac{w_j}{w_w} - a_{wj}\right| \right\}$$

subject to:

$$\sum_j w_j = 1 \tag{1}$$

$w_j \geq 0$, for all j.

Another model can be rewritten as follows [67].

$$\min \xi$$

subject to:

$$\left|\frac{w_B}{w_j} - a_{Bj}\right| \leq \xi, \text{ for all } j$$
$$\left|\frac{w_j}{w_w} - a_{wj}\right| \leq \xi, \text{ for all } j \tag{2}$$
$$\sum_j w_j = 1$$

$w_j \geq 0$, for all j.

Measurement Alternatives and Ranking according to Compromise Solution (MARCOS) method.

The MARCOS method is one of the ideal-anti ideal alternatives values [70].

Step 1. First, consider we have n criteria and m alternatives. R represents a set of experts.

Step 2. The decision matrix is created. The first row is anti-ideal (AAI), and the last row is an ideal (AI) solution: i represents as the row (alternatives), and j represents as column (criteria).

$$X = \begin{matrix} AAI \\ A_1 \\ \dots. \\ A_m \\ AI \end{matrix} \begin{bmatrix} x_{aa1} & x_{aa2} & \dots & x_{aan} \\ x_{11} & x_{12} & & x_{1n} \\ \vdots & & \ddots & \vdots \\ x_{m1} & x_{22} & \dots & x_{mn} \\ x_{ai1} & x_{ai2} & & x_{ain} \end{bmatrix} \tag{3}$$

$$AAI = \min_i x_{ij} \text{ if } j \in B \text{ and } \max_i x_{ij} \text{ if } j \in C \tag{4}$$

$$AI = \max_i x_{ij} \text{ if } j \in B \text{ and } \min_i x_{ij} \text{ if } j \in C \tag{5}$$

B shows a benefit group of criteria, and C points out to cost group of criteria.

Step 3. The decision matrix of (X) is normalized as follow as. The normalized matrix demonstrates as N = $[n_{ij}]_{m \times n}$.

$$n_{ij} = \frac{x_{ai}}{x_{ij}} \text{ if } j \in C \tag{6}$$

$$n_{ij} = \frac{x_{ij}}{x_{ai}} \text{ if } j \in B \tag{7}$$

x_{ij} and x_{ai} are the elements of matrix X.

Step 4. The weighted matrix V = $[v_{ij}]_{m \times n}$. Weighted matrix V is multiple of weighted into the normalized matrix. The weights are shown w_j.

$$v_{ij} = n_{ij} \times w_j \tag{8}$$

Step 5. The utility degree of alternatives is displayed as K_i. The utilities of ideal and anti-ideal alternatives are computed as follow as

$$K_i^- = \frac{S_i}{S_{aai}} \tag{9}$$

$$K_i^+ = \frac{S_i}{S_{ai}} \tag{10}$$

S_i ($i = 1, 2, \dots, n$) exhibits summation of elements of weighted matrix V.

$$S_i = \sum_{i=1}^{n} v_{ij} \tag{11}$$

Step 6. The utility function of alternatives $f(K_i)$. This utility function is created according to ideal and anti-ideal solutions alternatives. This utility function is obtained as follow as

$$f(K_i) = \frac{K_i^+ + K_i^-}{1 + \frac{1-f(K_i^+)}{f(K_i^+)} + \frac{1-f(K_i^-)}{f(K_i^-)}} \tag{12}$$

$f(K_i^-)$ points out to utility function of the anti-ideal solution, and $f(K_i^+)$ demonstrates the utility function of the ideal solution. The final utility function related to the ideal and anti-ideal solutions are

$$f(K_i^+) = \frac{K_i^-}{K_i^+ + K_i^-} \tag{13}$$

$$f(K_i^-) = \frac{K_i^+}{K_i^+ + K_i^-} \tag{14}$$

Step 7. The final ranking has done according to the final score of utility functions. The highest utility function score has the highest priority.

3.1. Customize Factors

This questionnaire distributes among eight DMs for answering these questions. The information of DMs is illustrated in Table 2.

Table 2. Information of DMs.

DM	Experiences	Certificate
DM 1	23	PhD
DM 2	21	PhD
DM 3	26	MSc
DM 4	25	MD
DM 5	21	MA
DM 6	23	PhD
DM 7	22	MSc
DM 8	27	MD

Then, the questionnaire distributes among them. The questionnaire is based on the five scale-Likert. If the average of responses was less than four, this factor was eliminated; otherwise, if the average of responses was equal or more than four, this factor was accepted. The results are shown in Table 3.

Table 3. The procedure of computation Delphi method.

	DM 1	DM 2	DM 3	DM 4	DM 5	DM 6	DM 7	DM 8	Average	Result
Business Owner's unwillingness	5	5	5	4	5	4	5	3	4.5	Accept
Unfamiliarity with Technology	4	5	5	3	4	5	5	4	4.375	Accept
Data privacy/security Concerns	4	4	4	5	5	4	3	4	4.125	Accept
Technological infeasibility	4	5	5	5	4	3	4	5	4.375	Accept
Complexity in set up/use	3	3	4	5	4	5	4	5	4.125	Accept
Uncertain benefits	4	4	5	5	3	4	5	4	4.25	Accept
Dependence on Blockchain operators	4	5	3	4	5	4	5	3	4.125	Accept
Lack of Cooperation among SC partners	3	4	5	4	5	4	5	3	4.125	Accept
Risks of cyber-attacks	4	5	4	4	5	4	5	3	4.25	Accept
Privacy Risks	3	3	3	4	5	4	5	3	3.75	Reject
Market-based Risks	3	4	5	5	4	3	3	3	3.75	Reject

In Table 4, the customized barriers and abbreviations of them are displayed.

Table 4. The abbreviation of customized barriers.

Barriers	Abbreviation
Business Owner's unwillingness	BO
Unfamiliarity with Technology	UT
Data privacy/security Concerns	DS
Technological infeasibility	TI
Complexity in set up/use	CS
Uncertain benefits	UB
Dependence on Blockchain operators	DB
Lack of Cooperation among SC partners	LC
Risks of cyber-attacks	RC

The result indicates that only nine barriers are accepted among eleven barriers, and two of them are privacy risks, and market-based risk barriers have been removed.

3.2. Research Procedure

Step 1. Extracting barriers to the implementation of SCM BC in blood supply by previous studies and interviews with experts.

Step 2. Screening barriers by Delphi method.

Step 3. Finding primary weights for barriers to implementation of BC by BWM.

Step 4. Prioritizing seven hubs of blood supply based on MARCOS method.

Figure 1 shows the research procedure.

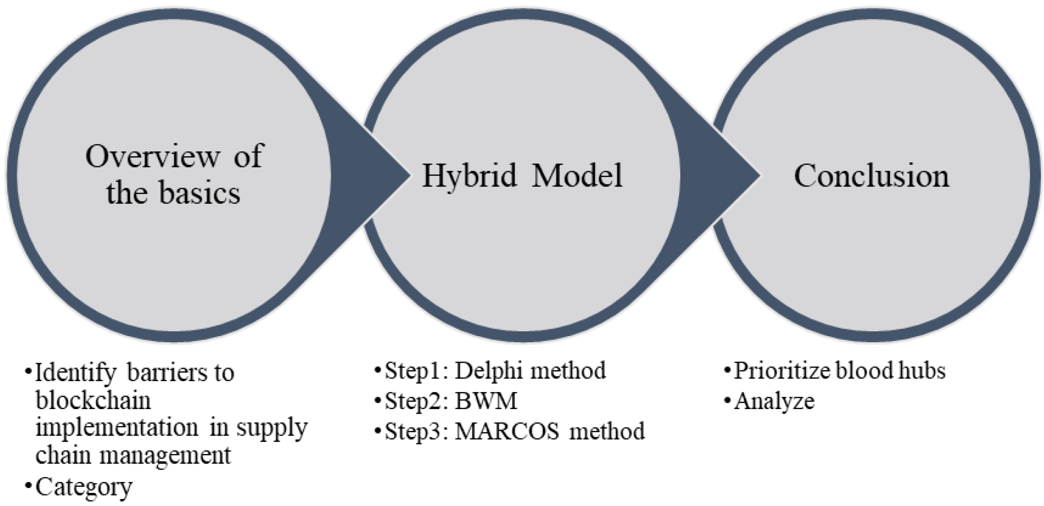

Figure 1. Research methodology procedure.

4. Data Analysis

In the first step, the best and worst criteria are identified. The best criterion is business owner's unwillingness, and the worst criterion is data privacy/security concerns. Then, DMs told their preference to each criterion compared with the best and worst criteria. The mode of DMs' preferences was selected as the final result. The preferences of DMs about best criteria are presented in Table 5. In the BWM, nine scale-Likert is used. For ranking best criteria, first, the best criterion was selected. Afterwards, this criterion was compared to other criteria and allocated within the nine scale-Likert based on the DM preferences.

Table 5. Best criteria preferences.

Best	BO	UT	DS	TI	CS	UB	DB	LC	RC
BO	1	8	7	9	6	8	9	5	8

In Table 6, the worst criteria preferences of DM are represented. In this table, the same process was conducted for similar best criteria.

Table 6. Worst criteria preferences.

DS	Worst
BO	4
UT	5
DS	1
TI	5
CS	4
UB	3
DB	4
LC	5
RC	4

In Table 7, the final weights of barriers are shown. Then, according to Equation (2), the linear programming was solved by LINGO software.

Table 7. Weights of barriers.

	BO	UT	DS	TI	CS	UB	DB	LC	RC
Weights	0.39	0.07	0.05	0.065	0.1	0.07	0.065	0.11	0.07

The Ks_i shows that the model's inconsistency rate points out that this model is reliable according to the guideline of Table 8.

Ks_i = 0.18.

Table 8. Consistency rate guideline.

Number of Criteria	3	4	5	6	7	8	9
Scale 9	0.21	0.36	0.4	0.42	0.44	0.45	0.47

Seven blood supply hubs provide blood and substantial materials extracted from blood. In this paper, these centers were ranked using the MARCOS method. The reason for ranking these hubs is finding which hub these barriers have a substantial effect on them and must focus on resolving these barriers and successfully implementing blockchain in blood supply SCM. In this table, the average of DMs' preferences is computed. These preferences are obtained based on nine scales Likert. Table 9 is the initial decision matrix created according to Equations (3)–(5).

Next, the normalized decision matrix is created according to Equations (6) and (7) and represented in Table 10. According to benefit and cost criteria and above equations, DMs' preferences are normalized in this step.

The weighted matrix shows in Table 11. In this step, normalized matrix multiple in weighted obtained from BWM. In this step, the weights that have been obtained from BWM for each criterion are multiple to the normalized table. It is based on Equation (8).

Table 9. The initial decision matrix.

	BO	UT	DS	TI	CS	UB	DB	LC	RC	BO
AAI	8.48	8.61	8.99	8.99	8.63	8.71	8.83	8.95	7.87	8.48
Hub 1	6.1	6.36	5.2	7.88	8.63	5.95	8.83	6.35	7.2	6.1
Hub 2	7.58	8.61	5.42	8.7	5.03	7.29	5.93	8.4	7.39	7.58
Hub 3	8.09	7.69	7.7	5.65	7.83	8.71	6.45	8.87	5.55	8.09
Hub 4	5.27	5.4	7.49	7.37	6.23	8.03	6.66	6.7	7.06	5.27
Hub 5	8.48	5.08	5.27	8.99	5.03	7.58	7.24	8.95	6.95	8.48
Hub 6	8.32	5.63	8.99	8.11	7.76	7.42	7.63	5.86	7.57	8.32
Hub 7	7.27	7.83	8.23	8.69	5.9	5.3	8.26	6.39	7.87	7.27
AI	5.27	5.08	5.2	5.65	5.03	5.3	5.93	5.86	5.55	5.27

Table 10. The normalized matrix.

	BO	UT	DS	TI	CS	UB	DB	LC	RC	BO
AAI	0.62	0.59	0.58	0.63	0.58	0.61	0.67	0.65	0.71	0.62
Hub 1	0.86	0.80	1.00	0.72	0.58	0.89	0.67	0.92	0.77	0.86
Hub 2	0.70	0.59	0.96	0.65	1.00	0.73	1.00	0.70	0.75	0.70
Hub 3	0.65	0.66	0.68	1.00	0.64	0.61	0.92	0.66	1.00	0.65
Hub 4	1.00	0.94	0.69	0.77	0.81	0.66	0.89	0.87	0.79	1.00
Hub 5	0.62	1.00	0.99	0.63	1.00	0.70	0.82	0.65	0.80	0.62
Hub 6	0.63	0.90	0.58	0.70	0.65	0.71	0.78	1.00	0.73	0.63
Hub 7	0.72	0.65	0.63	0.65	0.85	1.00	0.72	0.92	0.71	0.72
AI	1	1	1	1	1	1	1	1	1	1

Table 11. Weighted matrix.

	BO	UT	DS	TI	CS	UB	DB	LC	RC	BO
AAI	0.24	0.04	0.03	0.04	0.06	0.04	0.04	0.08	0.05	0.24
Hub 1	0.34	0.06	0.05	0.05	0.06	0.06	0.04	0.11	0.06	0.34
Hub 2	0.27	0.04	0.05	0.04	0.10	0.05	0.06	0.08	0.05	0.27
Hub 3	0.25	0.05	0.03	0.06	0.06	0.04	0.06	0.08	0.07	0.25
Hub 4	0.39	0.07	0.04	0.05	0.08	0.05	0.06	0.10	0.06	0.39
Hub 5	0.24	0.07	0.05	0.04	0.10	0.05	0.05	0.08	0.06	0.24
Hub 6	0.25	0.07	0.03	0.04	0.06	0.05	0.05	0.12	0.05	0.25
Hub 7	0.28	0.05	0.03	0.04	0.08	0.07	0.05	0.11	0.05	0.28
AI	0.39	0.07	0.05	0.06	0.10	0.07	0.06	0.12	0.07	0.39

In Table 12, utility degrees of alternatives, utility function and the final ranking of alternatives are displayed. The computation of finding final weights are obtained according to Equations (9)–(14).

Table 12. Final ranking.

	S_i	K_i^-	K_i^+	$f(K^-)$	$f(K^+)$	$f(K_i)$	Rank
AAI	0.63						
Hub 1	0.82	1.31	0.82	0.62	0.38	0.66	2
Hub 2	0.75	1.20	0.75	0.62	0.38	0.61	4
Hub 3	0.72	1.14	0.72	0.62	0.38	0.58	7
Hub 4	0.88	1.41	0.88	0.62	0.38	0.71	1
Hub 5	0.74	1.18	0.74	0.62	0.38	0.60	5
Hub 6	0.72	1.15	0.72	0.62	0.38	0.58	6
Hub 7	0.76	1.22	0.76	0.62	0.38	0.61	3
AI	1.00						

5. Conclusions and Managerial Implementation

Nowadays, SCM has a crucial role in all aspects of our lives that has been used in diverse industries and combined with other methods. One of the most critical matters in SCM is tracing the flow of receiving raw material and delivering final goods and services to end users. For the implementation of this work, many methods existed. One of these methods that use widely is blockchain. This method has been applied in many industries. Healthcare industries are one of the industries that play an essential role in people's lives, and a sensitive industry that 1 s is very crucial. Supply blood is significant for all hospitals and tracing the process of receiving blood, refining them, and then delivering it to hospitals' end users.

This paper sought to find prioritizing blood supply hubs according to barriers of implementation BC in SCM. Therefore, after prioritizing these barriers by BWM, business owners' unwillingness is the most crucial barrier for implementing BC in blood supply hubs. In other words, most of the blood supply hubs did not want to implement this technology. The reason is that they had less budget, and they must allocate it to very significant matters such as buying the technology of refining blood, getting the blood from volunteers and salary and benefit of staff. After prioritizing these hubs, the result indicates that among these hubs, hub four must be needed more attention on that for the elimination of implementation BC according to their barriers. This paper shows the road map of coping with tackles of performance BC in SCM of supply blood hubs. One of the merits of this road map is using hybrid MCDM methods with high accuracy.

To address the first research question, extraction barriers of implementation blockchain in blood supply are extracted from interviews with DMs and previous studies. However, implementing blockchain is not easy for all companies, and they face many barriers. In this paper, hubs of blood supply according to barriers of implementation of SCM BC are ranked to show which one has the highest priority for removing the barriers of implementation of SCM BC for supply blood. The business owner's unwillingness was the highest priority among the nine barriers to answering the second research question. Table 13 shows the rank of barriers.

This means that for the implementation of SCM BC, most top managers do not want to implement it because they have a low budget and think that the traditional method in supply blood is sufficient and do not need to implement BC. For answering the third question among seven hubs, hub 4 has the highest priority. It shows that managers must focus on hub four to eliminate BC barriers for implementing BC.

Several papers have been published about using BWM and MARCOS methods [40]. Still, using blockchain, especially in blood supply chain management, is very new. Hence, this paper can be opened new windows to this issue.

The method of receiving to deliver accuracy and acceleration is the most of the process.

Table 13. Rank of barriers.

Barriers	Rank
Business Owner's unwillingness	1
Unfamiliarity with Technology	4
Data privacy/security Concerns	6
Technological infeasibility	5
Complexity in set up/use	3
Uncertain benefits	4
Dependence on Blockchain operators	5
Lack of Cooperation among SC partners	2
Risks of cyber-attacks	4

All of this requires an ongoing and rigorous training program to familiarize all partners with the potentials and benefits of blockchain, which requires a great deal of time and financial resources.

The result of this paper has conflicted with some other researches. For instance, Vafadarnikjoo [49] uncertainty environment had the highest priority; however, it had fourth-order. This research has the same result as research Colak et al. [71] and Bag et al. [50] about the priority of barriers for implementation BC. In both research, management and in-desire implementation of BC because of lack of budget are the priority factors. However, in the study Ozdemir et al. [46], inter-organizational factors are the priority, which conflicts with the result of this paper.

For future research, researchers can work on the effect and relationship of barriers to each other by Decision-Making Trial and Evaluation Laboratory (DEMATEL), ISM, TISM, etc. Many of the most prominent players in the supply chain industry have embraced the blockchain-based distribution system and are spending resources to encourage others to use it. We will likely see global supply chains using blockchain to share information about a company in the coming years. Blockchain technology can change the way companies work in a variety of ways. These changes can include how raw materials are produced, products are produced, shipped, and products are supported. All events and changes can be recorded in a transparent and unchangeable system. So, the use of blockchain can eliminate many of the common inefficiencies in traditional management models.

Author Contributions: Conceptualization, A.K.Y. and I.M.-K.; methodology, A.K.Y.; software, A.M.; validation, I.M.-K.; formal analysis, A.K.Y.; investigation, A.M.; resources, A.K.Y.; data curation, A.K.Y.; writing—original draft preparation, A.K.Y. and A.M.; writing—review and editing, I.M.-K.; supervision I.M.-K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data of this study are available from the authors upon request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Helo, P.; Hao, Y. Blockchains in operations and supply chains: A model and reference implementation. *Comput. Ind. Eng.* **2019**, *136*, 242–251. [CrossRef]
2. Heidary Dahooie, J.; Zamani Babgohari, A.; Meidutė-Kavaliauskienė, I.; Govindan, K. Prioritising sustainable supply chain management practices by their impact on multiple interacting barriers. *Int. J. Sustain. Dev. World Ecol.* **2021**, *28*, 267–290. [CrossRef]
3. Kamble, S.S.; Gunasekaran, A.; Kumar, V.; Belhadi, A.; Foropon, C. A machine learning based approach for predicting blockchain adoption in supply Chain. *Technol. Forecast. Soc. Chang.* **2021**, *163*, 120465. [CrossRef]

4. Dwivedi, S.K.; Amin, R.; Vollala, S. Blockchain based secured information sharing protocol in supply chain management system with key distribution mechanism. *J. Inf. Secur. Appl.* **2020**, *54*, 102554.
5. Chopra, S. Designing the distribution network in a supply chain. *Transp. Res. Part E Logist. Transp. Rev.* **2003**, *39*, 123–140. [CrossRef]
6. Yazdi, A.K.; Wanke, P.F.; Hanne, T.; Bottani, E. A decision-support approach under uncertainty for evaluating reverse logistics capabilities of healthcare providers in Iran. *J. Enterp. Inf. Manag.* **2020**, *33*, 991–1022. [CrossRef]
7. Ellis, S.; Morris, H.D.; Santagate, J. IoT-enabled analytic applications revolutionize supply chain planning and execution. *Int. Data Corp. White Pap.* **2015**, *13*.
8. Song, J.M.; Sung, J.; Park, T. Applications of Blockchain to Improve Supply Chain Traceability. *Procedia Comput. Sci.* **2019**, *162*, 119–122. [CrossRef]
9. Di Vaio, A.; Varriale, L. Blockchain technology in supply chain management for sustainable performance: Evidence from the airport industry. *Int. J. Inf. Manag.* **2020**, *52*, 102014. [CrossRef]
10. Agrawal, T.K.; Kumar, V.; Pal, R.; Wang, L.; Chen, Y. Blockchain-based framework for supply chain traceability: A case example of textile and clothing industry. *Comput. Ind. Eng.* **2021**, *154*, 107130. [CrossRef]
11. Muessigmann, B.; von der Gracht, H.; Hartmann, E. Blockchain technology in logistics and supply chain management—A bibliometric literature review from 2016 to January 2020. *IEEE Trans. Eng. Manag.* **2020**, *67*, 988–1007. [CrossRef]
12. Queiroz, M.M.; Telles, R.; Bonilla, S.H. Blockchain and supply chain management integration: A systematic review of the literature. *Supply Chain Manag. Int. J.* **2019**, *25*, 241–254. [CrossRef]
13. Lu, Y. Blockchain and the related issues: A review of current research topics. *J. Manag. Anal.* **2018**, *5*, 231–255. [CrossRef]
14. Ghode, D.; Yadav, V.; Jain, R.; Soni, G. Adoption of blockchain in supply chain: An analysis of influencing factors. *J. Enterp. Inf. Manag.* **2020**, *33*, 437–456. [CrossRef]
15. Wang, Z.; Wang, T.; Hu, H.; Gong, J.; Ren, X.; Xiao, Q. Blockchain-based framework for improving supply chain traceability and information sharing in precast construction. *Autom. Constr.* **2020**, *111*, 103063. [CrossRef]
16. Queiroz, M.M.; Wamba, S.F. Blockchain adoption challenges in supply chain: An empirical investigation of the main drivers in India and the USA. *Int. J. Inf. Manag.* **2019**, *46*, 70–82. [CrossRef]
17. Karbassi Yazdi, A.; Hanne, T.; Osorio Gómez, J.C.; García Alcaraz, J.L. Finding the best third-party logistics in the automobile industry: A hybrid approach. *Math. Probl. Eng.* **2018**. [CrossRef]
18. Yazdi, A.K.; Wang, Y.J.; Komijan, A.R. Green supply chain management in an emerging economy: Prioritising critical success factors using grey-permutation and genetic algorithm. *Int. J. Logist. Syst. Manag.* **2020**, *36*, 199–223. [CrossRef]
19. Lohmer, J.; Bugert, N.; Lasch, R. Analysis of resilience strategies and ripple effect in blockchain-coordinated supply chains: An agent-based simulation study. *Int. J. Prod. Econ.* **2020**, *228*, 107882. [CrossRef]
20. Rawat, D.B.; Chaudhary, V.; Doku, R. Blockchain Technology: Emerging Applications and Use Cases for Secure and Trustworthy Smart Systems. *J. Cybersecur. Priv.* **2020**, *1*, 4–18. [CrossRef]
21. Esmaeilian, B.; Sarkis, J.; Lewis, K.; Behdad, S. Blockchain for the future of sustainable supply chain management in Industry 4.0. *Resour. Conserv. Recycl.* **2020**, *163*, 105064. [CrossRef]
22. Ferreira, F.A.F.; Meidutė-Kavaliauskienė, I. Toward a sustainable supply chain for social credit: Learning by experience using single-valued neutrosophic sets and fuzzy cognitive maps. *Ann. Oper. Res.* **2019**, 1–22. [CrossRef]
23. Ganguly, A.; Kumar, C. Evaluating Supply Chain Resiliency Strategies in the Indian pharmaceutical sector: A fuzzy analytic hierarchy process (F-AHP) approach. *Int. J. Anal. Hierarchy Process* **2019**, *11*, 153–180. [CrossRef]
24. Qian, X.A.; Papadonikolaki, E. Shifting trust in construction supply chains through blockchain technology. *Eng. Constr. Arch. Manag.* **2020**, *28*, 584–602. [CrossRef]
25. Gold, S.; Heikkurinen, P. Transparency fallacy: Unintended consequences of stakeholder claims on responsibility in supply chains. *Account. Audit. Account. J.* **2018**, *31*, 318–337. [CrossRef]
26. Sunny, J.; Undralla, N.; Pillai, V.M. Supply chain transparency through blockchain-based traceability: An overview with demonstration. *Comput. Ind. Eng.* **2020**, *150*, 106895. [CrossRef]
27. Modi, D.; Zhao, L. Social media analysis of consumer opinion on apparel supply chain transparency. *J. Fash. Mark. Manag. Int. J.* **2021**, *25*, 465–481. [CrossRef]
28. Morgan, T.R.; Richey, R.G., Jr.; Ellinger, A.E. Supplier transparency: Scale development and validation. *Int. J. Logist. Manag.* **2018**, *29*, 959–984. [CrossRef]
29. Zelbst, P.J.; Green, K.W.; Sower, V.E.; Bond, P.L. The impact of RFID, IIoT, and Blockchain technologies on supply chain transparency. *J. Manuf. Technol. Manag.* **2019**, *31*, 441–457. [CrossRef]
30. Yazdi, A.K.; Wanke, P.F.; Hanne, T.; Abdi, F.; Sarfaraz, A.H. Supplier selection in the oil & gas industry: A comprehensive approach for Multi-Criteria Decision Analysis. *Socio-Econ. Plan. Sci.* **2021**, *79*, 101142.
31. Saberi, S.; Kouhizadeh, M.; Sarkis, J.; Shen, L. Blockchain technology and its relationships to sustainable supply chain management. *Int. J. Prod. Res.* **2018**, *57*, 2117–2135. [CrossRef]
32. Azzi, R.; Chamoun, R.K.; Sokhn, M. The power of a blockchain-based supply chain. *Comput. Ind. Eng.* **2019**, *135*, 582–592. [CrossRef]
33. Shoaib, M.; Lim, M.K.; Wang, C. An integrated framework to prioritize blockchain-based supply chain success factors. *Ind. Manag. Data Syst.* **2020**, *120*, 2103–2131. [CrossRef]
34. Egels-Zandén, N.; Hulthen, K.; Wulff, G. Trade-offs in supply chain transparency: The case of Nudie Jeans Co. *J. Clean. Prod.* **2015**, *107*, 95–104. [CrossRef]

35. Aslam, J.; Saleem, A.; Khan, N.T.; Kim, Y.B. Factors influencing blockchain adoption in supply chain management practices: A study based on the oil industry. *J. Innov. Knowl.* **2021**, *6*, 124–134. [CrossRef]
36. Shahnaz, A.; Qamar, U.; Khalid, A. Using Blockchain for Electronic Health Records. *IEEE Access* **2019**, *7*, 147782–147795. [CrossRef]
37. Sadaphule, P.; Munot, P.; Narayani, R.; Ghodke, R.; Ghodke, S. Medical Supply Chain Management using Blockchain: An Overview. *New Arch—Int. J. Contemp. Archit.* **2021**, *8*, 1185–1191.
38. Pournader, M.; Shi, Y.; Seuring, S.; Koh, S.L. Blockchain applications in supply chains, transport and logistics: A systematic review of the literature. *Int. J. Prod. Res.* **2020**, *58*, 2063–2081. [CrossRef]
39. Hölbl, M.; Kompara, M.; Kamišalić, A.; Nemec Zlatolas, L. A systematic review of the use of blockchain in healthcare. *Symmetry* **2018**, *10*, 470. [CrossRef]
40. Meinert, E.; Alturkistani, A.; Foley, K.A.; Osama, T.; Car, J.; Majeed, A.; Van Velthoven, M.; Wells, G.; Brindley, D.; Lin, Y.; et al. Blockchain Implementation in Health Care: Protocol for a Systematic Review. *JMIR Res. Protoc.* **2019**, *8*, e10994. [CrossRef]
41. Angraal, S.; Krumholz, H.M.; Schulz, W.L. Blockchain technology: Applications in health care. *Circ. Cardiovasc. Qual. Outcomes* **2017**, *10*, e003800. [CrossRef]
42. Agbo, C.C.; Mahmoud, Q.H.; Eklund, J.M. Blockchain Technology in Healthcare: A Systematic Review. *Healthcare* **2019**, *7*, 56. [CrossRef]
43. Abou Jaoude, J.; Saade, R.G. Blockchain applications–usage in different domains. *IEEE Access* **2019**, *7*, 45360–45381. [CrossRef]
44. Hasselgren, A.; Kralevska, K.; Gligoroski, D.; Pedersen, S.A.; Faxvaag, A. Blockchain in healthcare and health sciences—A scoping review. *Int. J. Med Inform.* **2020**, *134*, 104040. [CrossRef]
45. Mathivathanan, D.; Mathiyazhagan, K.; Rana, N.P.; Khorana, S.; Dwivedi, Y.K. Barriers to the adoption of blockchain technology in business supply chains: A total interpretive structural modelling (TISM) approach. *Int. J. Prod. Res.* **2021**, *59*, 3338–3359. [CrossRef]
46. Ozdemir, A.I.; Erol, I.; Ar, I.M.; Peker, I.; Asgary, A.; Medeni, T.D.; Medeni, I.T. The role of blockchain in reducing the impact of barriers to humanitarian supply chain management. *Int. J. Logist. Manag.* **2021**, *32*, 454–478. [CrossRef]
47. Biswas, B.; Gupta, R. Analysis of barriers to implement blockchain in industry and service sectors. *Comput. Ind. Eng.* **2019**, *136*, 225–241. [CrossRef]
48. Kouhizadeh, M.; Saberi, S.; Sarkis, J. Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers. *Int. J. Prod. Econ.* **2021**, *231*, 107831. [CrossRef]
49. Vafadarnikjoo, A.; Ahmadi, H.B.; Liou, J.J.H.; Botelho, T.; Chalvatzis, K. Analyzing blockchain adoption barriers in manufacturing supply chains by the neutrosophic analytic hierarchy process. *Ann. Oper. Res.* **2021**, 1–28. [CrossRef]
50. Bag, S.; Viktorovich, D.A.; Sahu, A.K.; Sahu, A.K. Barriers to adoption of blockchain technology in green supply chain management. *J. Glob. Oper. Strateg. Sourc.* **2020**, *14*, 104–133. [CrossRef]
51. Tandon, A.; Dhir, A.; Islam, A.N.; Mäntymäki, M. Blockchain in healthcare: A systematic literature review, synthesizing framework and future research agenda. *Comput. Ind.* **2020**, *122*, 103290. [CrossRef]
52. Shermin, V. Disrupting governance with blockchains and smart contracts. *Strat. Chang.* **2017**, *26*, 499–509. [CrossRef]
53. Venkatesh, V.G.; Zhang, A.; Deakins, E.; Luthra, S.; Mangla, S. A fuzzy AHP-TOPSIS approach to supply partner selection in continuous aid humanitarian supply chains. *Ann. Oper. Res.* **2019**, *283*, 1517–1550. [CrossRef]
54. Goswami, M.; Daultani, Y.; De, A. Decision modeling and analysis in new product development considering supply chain uncertainties: A multi-functional expert based approach. *Expert Syst. Appl.* **2021**, *166*, 114016. [CrossRef]
55. Choudhary, A.; De, A.; Ahmed, K.; Shankar, R. An integrated fuzzy intuitionistic sustainability assessment framework for manufacturing supply chain: A study of UK based firms. *Ann. Oper. Res.* **2021**, 1–44. [CrossRef]
56. Governatori, G.; Idelberger, F.; Milosevic, Z.; Riveret, R.; Sartor, G.; Xu, X. On legal contracts, imperative and declarative smart contracts, and blockchain systems. *Artif. Intell. Law* **2018**, *26*, 377–409. [CrossRef]
57. Paech, P. The Governance of Blockchain Financial Networks. *Mod. Law Rev.* **2017**, *80*, 1073–1110. [CrossRef]
58. Yazdi, A.K.; Komijan, A.R.; Wanke, P.F.; Sardar, S. Oil project selection in Iran: A hybrid MADM approach in an uncertain environment. *Appl. Soft Comput.* **2020**, *88*, 106066. [CrossRef]
59. Kaviani, M.A.; Yazdi, A.K.; Ocampo, L.; Kusi-Sarpong, S. An integrated grey-based multi-criteria decision-making approach for supplier evaluation and selection in the oil and gas industry. *Kybernetes* **2019**, *49*, 406–441. [CrossRef]
60. O'Donoghue, O.; Vazirani, A.A.; Brindley, D.; Meinert, E. Design choices and trade-offs in health care blockchain implementations: Systematic review. *J. Med. Internet Res.* **2019**, *21*, e12426. [CrossRef]
61. Gromovs, G.; Lammi, K. Blockchain and internet of things require innovative approach to logistics education. *Transp. Probl.* **2017**, *12*, 23–24. [CrossRef]
62. Yli-Huumo, J.; Ko, D.; Choi, S.; Park, S.; Smolander, K. Where is current research on blockchain technology?—A systematic review. *PLoS ONE* **2016**, *11*, e0163477. [CrossRef] [PubMed]
63. Chang, Y.; Iakovou, E.; Shi, W. Blockchain in global supply chains and cross border trade: A critical synthesis of the state-of-the-art, challenges and opportunities. *Int. J. Prod. Res.* **2020**, *58*, 2082–2099. [CrossRef]
64. Yadav, S.; Singh, S.P. Blockchain critical success factors for sustainable supply chain. *Resour. Conserv. Recycl.* **2020**, *152*, 104505. [CrossRef]
65. Behnke, K.; Janssen, M. Boundary conditions for traceability in food supply chains using blockchain technology. *Int. J. Inf. Manag.* **2020**, *52*, 101969. [CrossRef]

66. Okoli, C.; Pawlowski, S.D. The Delphi method as a research tool: An example, design considerations and applications. *Inf. Manag.* **2004**, *42*, 15–29. [CrossRef]
67. Rezaei, J. Best-worst multi-criteria decision-making method. *Omega* **2015**, *53*, 49–57. [CrossRef]
68. Gan, J.; Zhong, S.; Liu, S.; Yang, D. Resilient Supplier Selection Based on Fuzzy BWM and GMo-RTOPSIS under Supply Chain Environment. *Discret. Dyn. Nat. Soc.* **2019**, *2019*. [CrossRef]
69. Muneeb, F.M.; Yazdi, A.K.; Wanke, P.; Yiyin, C.; Chughtai, M.S. Critical success factors for sustainable entrepreneurship in Pakistani Telecommunications industry: A hybrid grey systems theory/best-worst method approach. *Manag. Decis.* **2020**, *58*, 2565–2591. [CrossRef]
70. Stević, Ž.; Pamučar, D.; Puška, A.; Chatterjee, P. Sustainable supplier selection in healthcare industries using a new MCDM method: Measurement of alternatives and ranking according to COmpromise solution (MARCOS). *Comput. Ind. Eng.* **2020**, *140*, 106231. [CrossRef]
71. Çolak, M.; Kaya, I.; Özkan, B.; Budak, A.; Karaşan, A. A multi-criteria evaluation model based on hesitant fuzzy sets for blockchain technology in supply chain management. *J. Intell. Fuzzy Syst.* **2020**, *38*, 935–946. [CrossRef]