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Expert oriented approach for analyzing the blockchain adoption barriers in humanitarian supply chain

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ABSTRACT

In digital era, blockchain technology has been known as the operational innovation that is rapidly joining the context of humanitarian supply chain and relief logistic. Hence, it has the potential to change the humanitarian context fundamentally, but there is still relatively little-published research aimed at improving the understanding of the different barriers of the blockchain adoption in humanitarian supply chain. The goal of this research is to present a comprehensive review of blockchain adoption barriers in the context of humanitarian supply chain management. An integrated approach using Fuzzy Delphi and Best-Worst method (BWM) has been used for analyzing the barriers. Based on the literature, 14 barriers of the blockchain adoption in humanitarian supply chain were identified. According to the Fuzzy Delphi result, 9 barriers were accepted. After that, the BWM calculated the importance of each barrier. The findings showed that regulatory uncertainty, lack of knowledge/employee training and high sustainability costs are the important barriers. This research provides useful guidelines for policy makers so that they can benefit from the results to optimize their solutions.

1. Introduction

As a state-of-the-art technology and a seemingly disruptive innovation after the emergence of the transmission control protocol/internet protocol, blockchain functions based on the distributed ledger technology have been defined as a distributed implementation of digital ledgers. Blockchain owes its popularity to Nakamoto as the mysterious founder of Bitcoin, which was introduced as a decentralized digital currency to the world [1]. Transcending crypto currency, according to Refs. [2,3], modern usage of blockchain covers intelligent E-government [4], digital transformation [5], electronic retailing in Newegg, products' origin in Ever ledger Limited, Expedia booking services for travel, shipping in Maersk [6], connected transport or smart cars and supply chain management of Johnsonville and Maple Leaf Foods [7]. The technology of blockchain is quickly transforming daily transaction mechanisms integrated with digital instruments. In other words, this technology has paved the way for smart contract and crypto currency. Despite defects, including high-energy consumption and privacy issues, a new digital transaction age is started. This issue has also significantly affected humanitarian sectors [2]. Blockchain characteristics such as trustless decentralized ledgers throughout peer-to-peer networks provide potential for eliminating corruptive actions based on improving accountability and transparency, which affects smart contract, supply chain management and digital identity as well as the financial sector [4]. Humanitarian institutions are indeed willing to promote transparency accountability and efficiency by proposing the notion of integrating private and public fund tools into blockchain. The usefulness of blockchain can manifest itself as technological plans for tracing and distributing aid fund, managing and providing identification in refugee camps and developing a reliable land registry; nevertheless, the likelihood of risks associated with privacy issues cannot be denied in this regard. Many researchers have reported the usefulness of blockchain; for instance, Michael Fauscette, the chief research officer of G2 Crowd, who reported digital transformation trends in 2018, emphasized blockchain as a means of returning identity to individuals in the absence or unwillingness of the government [8]. He also highlighted the sweeping security of the technology and its presumably theoretical cyber risks. On the other hand, given the complication and electrical consumption of blockchain and its need for accessing the internet, doubts were raised over its reliable applicability in humanitarian disasters [9]. Blockchain application is facing numerous challenges and barriers, especially in a humanitarian supply chain that requires to be addressed outright [10,

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11]. Hence, it is essential to identify and prioritize the barriers, which are responsible for the adoption of blockchain technology in humanitarian supply chains. The purpose of this research is to find the most important barriers in research literature and background and prioritize them.

The remainder of this paper is organized as follows. In Section 2, we illustrate the literature review and present an overview of humanitarian supply chain, blockchain technology and blockchain adoption barriers based on existing studies. In Section 3, we highlight the research methodology and apply our proposed framework. In Section 4, we present the results from the applied framework. In Section 5, we discuss the managerial implications of the obtained results and highlight the future scope.

2. Review of literature

2.1. Humanitarian supply chain

A supply chain contains different sections that are interested directly or indirectly in satisfying a customer's demand. Humanitarian supply chain is one of the latest concept in the supply chain literature [12]. Two fundamental terms, in the context of humanistic supply chain are long-term development and disasters concerns. Long-term development matters produce human suffering and agony in an extended condition, and usually, their causes cannot be followed back to an individual calamitous event [13]. Because of the increased number of both man-made and natural disasters across the world, the academic community has shown renovated interest in this issue, in contemporary times. Therefore, diverse modeling methods, and some methodologies and technologies have been applied in various stages of the disaster life cycle to classify some new survey papers [14–17]. The unrivalled challenges and characteristics of humanistic supply chain are being analyzed in current literature. Those challenges of logisticians in humanitarian course count on both the local appearance of their employer and types of disaster are recognized in Ref. [18]. Cooperation of activities in logistical issues are distinguished as the main challenge by researchers [19]. Exams either for-profit steady supply chain procedures are appropriate in the non-profit humanitarian supply chain position. They argue that in the humanitarian supply chain condition, supply chain techniques and tools designed for benefit situation, specifically for performance assessments and partnership formation. The chief distinguishing features between the non-profit and for-profit supply chain with respect to sources of fund, targets of the stakeholders, the organization and performance assessment criteria revised and reviewed by Ref. [20]. The main aim in for-profit methods is financial return to the shareholders, whereas to obtain the social goals and mission effectively is in non-profit one [21].

As study on humanitarian supply chain is more concentrated about disaster, literature is relevant to the long-term humanitarian supply chain [22]. Attaches aid recipients (beneficiaries) to the list while emphasizing the distinction between international and national community-based organizations. Humanitarian supply chains include more than only humanitarian organizations [23]. Recommended recovery, readiness, response, and mitigation [24]. Highlighted avoidance, transition, and recovery [25], enumerated donors, aid organizations, NGOs, governments, army, logistics service providers, and suppliers as actors of HSC [26]. Specifies emergency relief, rehabilitation, and development , [27] and readiness, response, and recovery [28] are important phase of HSC. Realized and achieved the optimal procurement policy, and analyzed inventory management are important issue in humanitarian organization under budget limitations over a limited planning period [29]. Indicated the level of improved efficiency in respect to handling extra volume, which was achieved without investing in extra warehouse place and reflected the warehouse operations in a non-profit food supply chain. Some examples like food security and health care are considered in the application of operation research to develop the effectiveness of the system in long-term humanitarian supply chain in some literature parts [30–32].

2.2. Blockchain technology

Blockchain is mostly applied in different cryptocurrencies. The appearance of Ethereum in 2014 is the first important progression of blockchain technology [4]. Nevertheless, an obligatory element of blockchain projects is still the cryptocurrency requiring the consensus for the disposed ledger and the core part to keep trust. The Linux foundation formally introduced Hyperledger in 2017, which is its open source project and is presented as the third generation of blockchain in advertisement. The key characteristic of blockchain projects is the view of 'smart contract' and from then on, the cryptocurrency stops to be a native element [33].

Today, in 4 dimensions including (1) a cryptography behind, (2) a distributed ledger, (3) the smart contracts and (4) the choice of consensus protocol, the blockchain application could be discussed. Blockchains are distributed peer-to-peer networks, in technical terms, that are immutable, append-only, up-to-date only through peer consensus and cryptographically safe (they are very difficult to change) [34]. Blockchain which runs on high part of the internet protocols is another application layer, and without needing a trusted third party, allow economic transactions between related parties [35]. As inventory and registry systems for the tracing, recording, contracting of every asset, monitoring and whether electronic or physical, legal and financial blockchains can also be used [36]. Over a given period, a list of transactions is registered to a log, creating a 'block' in a blockchain system. As each transaction happens, it is put into a block. Before and after it, each block is joined to the blocks. By means of a hashing function, these blocks are mathematically 'connected or chained' together; within the blockchain, we could consider a hash as a digital fingerprint of data to jail it in setting [37]. When they are matched in a chain, these blocks become immutable and by a single actor, they cannot be omitted or changed. Instead, by automation and contributed governance protocols, they are handled and verified [38]. In addition, by blockchain knots (the users/computers taking part in a blockchain network), the verification is done. No single node governs the data and each node consists of a total record of entire transactions ever penetrated in that blockchain.

Usually, most of knots in the blockchain network must endorse the biography (history) of the suggested single block and accomplish algorithms to assess, especially when an adaption to a present contract or a new transaction go in a blockchain. If the history and signature of most nodes entered to a consensus are authentic, a new block is attached to the series of contracts and the modern block of contracts is admitted into the log [37]. Consequently, by applying advanced encryption methods, the verification process can efficiently save the data in blockchain logs against invalid manipulation or access. Participants always have access to an extensive analysis of activities by securing this setup [39]. To innovate a self-regulating system without the requirement of third groups, the exceptional essence of blockchains exists in their capability to insist on the rules. Instead, by means of a consensus algorithm, the enforcement is performed. Blockchains hence 'program' the much-needed 'trust' in digital systems demanded by some people [40]. Over the control access mechanism, there are two kinds of blockchains (i.e. it shows who can take part in the consensus process, read a blockchain, and give transactions to the blockchain):

✓ Permitted blockchains. In this kind, participators should receive an invitation or in contrast, have permission to connect. A single organization (private blockchains) or by consortium blockchains (members of consortium) tends to control the access.

✓ Public blockchains. In this kind, users can be kept anonymous and all contracts are public (thereby 'permission less'), in order to stimulate more participants to connect the network, the network typically has an incentivizing mechanism. A typical example is Bitcoin.

2.3. Blockchain in humanitarian supply chain

In multiple industries, the potential of blockchain has been discovered. The technology suggests the disintermediation process (substituting the middlemen by blockchain technology), by which almost every industry can be disturbed [9]. Also, blockchain is the next humanitarian aid industry disrupter, which is supported by many blockchain fans [41]. For transferring financial humanitarian aid, blockchain technology can potentially be applied for cash transfer.

Therefore, it can only be applied to transfer cash by using blockchain in the humanitarian supply chain. Blockchain has the capability of creating the aid industry by making it more digitized and future-fit, chiefly by transferring cash and stepping away from in-kind donations since aid agencies are struggling for a more direct transfer of aid. By means of national banks or the government, blockchain technology recommends a protocol to cash control. Therefore, blockchain is secure from fraud because it is not possible to remove blocks from the transaction, and for getting lost to corrupt governments, it is suggested a way to prevent financial aid. Formerly, duo to lack of trust, it was tried to analyze how aid agencies are doubtful to make the shift to cash transfers. They were worried that the cash might not reach the intended goal and be finished in the wrong hands. Moreover, it means that the cash can be traced back and the transaction will be completely transparent. More affected people can receive the assistance they deserve, if blockchain could be enabled less, in-kind donations would come to waste, more aid agencies to switch to cash and aid delivery would become more efficient. If blockchain has been praised for the positions it suggests, it does not come as any surprise. Generally, the profit of blockchain is that it is a decentralized system, with the service of a permissionless blockchain. No centralized institution possesses the blockchain. Thereby, in theory, problems can be eradicated are fundamental to the humanitarian help supply chain.

2.4. Blockchain adoption barriers

There are also some important barriers to blockchain adoption, in spite of the immense capability of blockchain technology.

2.4.1. Scalability issues

Scalability is the capability of blockchain calculating processes to apply in a vast range of potentialities and to fulfil these aims. This is a significant issue. Actually, 60% of business executives stated that, primarily due to scalability issues, executing blockchain was harder than they initially assumed [42]. Especially, it is described that blockchain technology capability decreases latency (the delay or the time interval when a component of a system is holding on and waiting for other system element to carry out a task) while it meets an aimed level of processing output [43]. In contrast to bitcoin (public blockchain application) that handle only approximately seven transactions per second, Ethereum (a kind of public open source blockchain created to protect applications which is decentralized for example intelligent contracts) handles approximately 20 contacts per second since blockchain technology is computationally comprehensive [44].

2.4.2. Integrating Problems

The complicated process of integrting blockchain software with legacy systems is another main barriers related to blockchain technology adjustment. This is not only a substitute of their current systems, but also for a particular business goal in majority of organizations for executing or implementing the contemplation of blockchain technology. Additionally, to contribute data effectively, those systems may be required to interact with one another if multiple blockchains are applied. "For the integration process, conflicts with existing platforms, an analysis of data security, and possible bottlenecks, will be needed" [33]. The combination of blockchain technology with present systems is expensive to fulfil and time-consuming. The combination of blockchain technology with various legacy systems or within the blockchain ecosystem, are parts of the reason for the high cost due to the lack of standard, off-the-shelf interfaces, that will possibly require to be customized keys. Hence, it still requires creating application programming interface (API) gateways in order to encounter new blockchain consortium applications with legacy systems. The present legacy systems are not possibly consistent with blockchain technology; therefore, it is demanding that the implementation costs of blockchain be completely replaced and attached to them [45].

2.4.3. Lack of standardization

Decentralization is essential process of blockchain technology [43]. Blockchain coders and developers obtain a kind of great donation, called freedom due to the decentralized and scattering nature of blockchain so that they are able to accommodate systems to the requests of special consumers. Due to the scarcity of standardization of information technology (IT) departments, they cannot be recognized without translation help, and platforms cannot convey and communicate well [45]. In line with a research by Deloitte, the most famous software cooperation platform is GitHub with over than 68 repositories (the software of projects presenting code), 337 diverse languages and more than 24 million users that is called a cloud-based code repository. On GitHub, different platforms with several protocols, privacy measures, consensus, coding languages and mechanisms are presented in blockchain projects [46]. In addition, the absence of standardization hinders blockchain members to be able to communicate and cooperate efficiently, even though for developers and coders. The decentralized feature of blockchain provides more latitude in fulfilling their aims.

2.4.4. Complexity of establishing

It is a highlighted survey, that presented the complication and costs related "to establishing blockchain keys as the main barriers to the adjusting the technology" in Deloitte's 2018 Global Blockchain [45]. An important start-up expense for industries and companies that adjust the technology is a need to moving from legacy IT systems to systems based on blockchain. The adoption can be obstructed by integration issues, complicated programming, a lack of blockchain improvement talent, and testing.

In addition, its complexity is added to innovative methods for emphasizing scalability while obtaining security, and storage concerns as well. Finding out improving relevant governance structures, balancing the sharing tradeoffs (segmenting the data base so that every transaction is not managed by all nodes) and the clue of modern consensus mechanisms are a few of the matters that the blockchain technology adopters must surmount. Better blockchain templates, platforms, and tools help decrease the hardship of blockchain complexities, to facilitate the lack of skills and act like a service cloud providers (BaaS) like, Microsoft, Amazon, and IBM as well. Nevertheless, emphasizing the resources of blockchain diversity occur at a price, whether handled in-house or outsourced.

2.4.5. Regulatory uncertainty

Frequently, the technological progress of blockchain has led to the improvement of a relevant legitimate framework, with disturbing technologies. In a Survey by Deloitte's 2018 Global Blockchain, it was mentioned that 39% of respondents cited "regulatory items" that prevented firms from causing investments in blockchain technology that was categorized as the most crucial item [42]. "The cause and reason are the introduction of some method and concepts by technology for instances intelligent contracts and cryptographic signatures that do not emphasize present and existing laws" [42]. It shows that "blockchain ledgers could be dependent on international jurisdictions or various state, because they exist on nodes in several locations, therefore conflict with tax regulations and current legal explanation and definitions" [33]. These matters intensify the request of new standard backbones that emphasize the legalized concerns increased over appearing application in different legal settings and businesses.

2.4.6. Lack of knowledge/employee training

Businesses, in the most primary stage, face problem for finding and keeping employees who have the knowledge and essential skills in order to perform efficiently with blockchain technology. In all industries, employees with a skill based on blockchain, clearly warrant premium recovery and significant demand are put forward for expanding technology with the capability to obstruct the out-of-date methods to accomplish businesses. Furthermore, businesses, without some sufficient certified and skillful employees cannot be capable of recognizing the full profits related for executing blockchain technology [34]. Blockchain technology is only restricted to financial services industry and cryptocurrencies on more macro level according to the belief of most business administrators. Consequently, administrators in industries like automotive, agribusiness, consumer products sectors, oil and gas and health care, who are misunderstood blockchain's abilities, may be neglecting—at their own peril— the capability to ameliorate data security and transform the manner in which their businesses are done in an appearing technology for main cost savings [2].

2.4.7. Market-based risks

There are constant fear among blockchain users for payment merchants that can be adjusted with the modern tool in the future time [47–49]. Apart from that, the whole attempt for launching blockchains as an innovative platform for various industries can become fruitless. In addition, because of the comparatively low attainability of the tools based on blockchain in the real market, blockchain users encounter an unusual flimsy market problem [50–52]. Thus, without overturning the entire market, a person who is willing to trade or withdraw with a great deal of tools, cannot do well. Generally, users may be tempted to store their tools with such uncertainty in the recent market.

2.4.8. Technology Risks

Blockchains ache from harsh technology challenges, but traditional application software and Operating Systems are free from this issues; an instance of this issue is the complex installation of extended software promotion over all mining computers. Frequently, the protocol updates can be reel really owing to the existance of a bug in software, or incompatibilities in a specific user blocks so that the whole blockchain may be impelled to slit [53]. Every user in the network has to be consistent and roll back their updates and upgrades in the complete blockchain. Afterwards, trained users in the network have to be discreet because deliberate updates for software protocol are problematic to perform, and often deliberately hinder such activity. Through blockchain, with the loss of keys related to cryptographic, another widespread problem can take place. If in blockchain, some private/public information, keys, and cues are lost, stolen, or expired, these blocks cannot be regained [54]. Even though these keys may be presented physically in the blockchain network, and cannot be removed or excavated any more. In contrast to any other centrally directed economical tools, this scene indicates an enormous challenge when applying blockchain.

2.4.9. High sustainability costs

Through digging networks, a massive electrical energy is required to perform the difficult calculations and to extract blockchain as well. By means of applications related to blockchain, extracting, performed by the power consumption of a personal computer that largely excels the monetary rewards, can be ultimately generated. In situations like this, by applying personal computers, there is a missing proposition for diggers to extract blockchains [53,55]. Structure of processor in computer is developing, and the whole part of network can use potency and power, to highlight a megacity. In addition, in universal financial market, the relevant rewards are increased with an increase in the value of blockchain-based economical tools, thus more miners are absorbed to carry out their tasks on the network. Unluckily, the increase of network load and calculation are not conveyed into larger financial benefits. Also, the problem of establishing perpetual blockchains can be increased by scalability concerns [55,56].

2.4.10. Low/no transaction fees

Before activating the entire network, a crucial mass of users are essential to cumulate because execution, implementation, and adoption in blockchain is an expensive proposition. Initially, miners are applied to solve puzzles and finally rewards are given in currencies in the current cryptocurrency frameworks. Nevertheless, the number of related miners will be raised while a blockchain network improves in size. Consequently, those puzzles will become more highly developed, and related rewards will decrease extremely. Step by step, due to the extended calculation to essential resources, it cannot be beneficial to dig blockchains [49]. Recently, by applying a blockchain network, no payment is done. Nevertheless, the subscription fee will be received from all users and the network will permeate when adoption raises. In order to support the information systems adoption for example ERP, software products, and telecommunications, same payment mechanisms have been performed [57]. In addition, the influence of a volatile economy and unstable market can be neglected in modern models of blockchain [58]. The fancies of the present blockchain users is the choice of decision because the decentralized character of blockchain protocols evades the interruption of any centralized financial exchange or institution. Lastly, research has indicated that within small blockchain networks and among miner groups, fraudulence is possible. Thus, the nature of the decentralized character of these platforms is controversial. Five industry specialists believe that cartelization and miner banding are conducted to returns to criteria, by which small miners gradually would be eradicated from the marketplace [53].

2.4.11. Risks of Privacy

For blockchain users, transactions can be conducted for important privacy issues. The blockchains privacy protocols in papers of [59] are discussed revealing that majority of users are not aware of backup mechanisms and the inbuilt privacy designs. Main transactions are implemented across the internet, in a public blockchain, in which by analyzing previous transaction block, the uniqueness of the included parties can be uncovered immediately. Thereby their validity details are obtainable [60]. Furthermore, if a contract error exists, from the error log, users can pursue him/her. Finally, the anonymous user is exposed and compromised. Nevertheless, this kind of anonymity can be harmful and damaging to the entire users, if some malevolent user is involved in illegal activity. On the other hand, nobles are unaware of the exact identification of one another in a private blockchain network, and mutual trust the consensus on all transaction. So instead of being a clear platform for clear and recognizable business mechanisms, a blockchain may act as a private cartel [61]. In addition, in blockchains, data privacy concerns can be conducted to govern the results; one industry specialist mentioned. For example, users might encounter harsh problems, if electronic health records are located across the blockchain network and whose records are breached. As a result, the privacy of location requires to be attained for all users, so that agreement and compliance concerns and data government can be monitored [62,63].

2.4.12. Usage in underground economy

Traders and businesses, who deal with controversial and illicit property, were the introductory adopters in blockchain technology. Otherwise, that would be inhibited by regulation and law. Frequently, in order to prepare the financial framework to this kind of transactions, cryptocurrencies were applied, that implemented, executed and hosted by means of Tor such as Darknet [49]. Lately, as payment ways and methods, other money laundering activities and gambling have started to apply blockchains. While, there was a prohibition in the Silk Route marketplace, where the bitcoin prices 1, an acute decline was an example of its instantaneous impact. Also, two academic experts and nine industry professionals endorsed the use of blockchains networks in subway finance that could endanger their high-scale adjusting in key services and industries.

2.4.13. Risk of cyber-attacks

Infrastructure obstructions and a denial of service (DoS), two examples of network-based raids, can cause congestion and delays in the blockchain network, which change the information reached through user knots and twist their viewpoints of the shelf [64]. Over submerging the nodes with forged demands, a DoS raid and rush are targeted to disturb the common operation in blockchain network. The present algorithm named Proof-of-Work is highly unprotected to raids. By the same token, a DoS attack can be commenced by an attacker on a P2P blockchain without accepting the well-timed transport of mined blocks [65]. Furthermore, if a pool on the blockchain network or a computationally powerful node intends to raise its payoffs for mining, it can go off from the present protocol named Proof-of -Work, via particularly keeping blocks from spreading [66]. Through this mode, while an individual miner can monitor above 33% resources calculation in overall network, conceited mining invaders can collect larger force truthful nodes and revenues to adjust. Once more [66], it begins by doubled spending raids and attacks where, an individual block can be reused by that miner for several times [67].

2.4.14. Contractual risk

The risk related to the administration and development of transactions to control and monitor the entire relations inherent for the development of blockchain is partially associated with vendor risk. Additionally, service-level agreements (SLAs) and vendor relationships are essential to explain and handle the relations among all the participating nodes and the blockchain administrator [8]. Consider that the privileges and rights of participators in blockchain can differ vastly, and for each relationship, unique SLAs are needed. Efficient SLA enforcement, controlling and monitoring are crucial to have a successful event and experience in blockchain.

In this sub-section, we identify the barriers from extant literature and feedback from experts. Next, As mentioned above, we summarize these barriers into 14 significant categories based on our initial discussion with the experts, present them in Table 1.

The literature review of blockchain adoption indicates that majority of the researches have focused on a detailed analysis on the obstructions that hinder the satisfactory adjustment of blockchains in humanitarian supply chain. Furthermore, on cryptocurrencies, practice and academia have massively emphasized blockchain adjusting. [50], for instance, have discussed various concerns and risks associated with cryptocurrencies. A technology acceptance model has been indicated by Refs. [72] to analyze related risks and the perceived profits as the main preventions of bitcoin use. Lately, relevant questions have been increased about opportunities for blockchain adjusting consumers and the possible risks [10].

Even then, it is understood that the remaining literature requires an individual extensive study, that diagnose the main obstructions, classify them in line with their significance. As a result, it highlights the obstructions to successful blockchain adjusting in humanitarian supply chain, with the inputs from experts and literature. After that, it was discussed the barriers, and lastly, they are categorized in this study. Then we analyzed the barriers, and finally ranked them. Briefly, we addressed the following research questions:

RQ1. What are the barriers to a successful implementation of blochchain technology across humanitarian supply chain?

RQ2. Among them, what are the prominent barriers that need immediate attention from managers?

3. Research methodology

This research employs inductive approaches to conclude a set of rewards associated with blockchain adoption barriers in humanitarian supply chains. This study uses the fuzzy Delphi method to discover and screening the blockchain adoption barriers. Other applied method is BWM that benefited effectively for the ranking the blockchain adoption barriers. For some articles in English-speaking journals, we did a systematic search, to fill the research gap. The bibliographic databases searched include Science Direct, Wiley, Springer, Taylor & Francis, Emerald, Google Scholar and Web of Science. Up to now, the search approved that with a focus on blockchain adoption barriers in humanitarian supply chains that help to get better understanding for the research gap, no study has been published. The data required for the existing study was gathered through different resources like archival data, which consisted interviews with experts, organization booklet, documents, and brochures. A decision team of 6 experts took part in the procedure of data gathering, and in Table 2, their background is shown.

Due to the experience, and position within their organizations, the specialists chose the panel named Delphi. The writers preffered qualitative methods for data collection, specifically, semi-structured interviews, when they prepare a more productive data source than quantitative approaches [77]. Because this research is the explorative one, we launch the data collection process, after finishing the panel by the experts. Lastly, the experts' answers and responses were gathered. A review of literature, a questionnaire and semi-structured interviews are data gathering tools. The primary tool was carried out to reveal an introductory literature in research. We used both keywords of blockchain adoption and humanitarian supply chain in our literature review. Afterwards, experts identified the blockchain adoption barriers in humanitarian supply chain, with review the research literature. Those two stages were conducted for the arrangement of obstructions encountering in practice by experts [78]. The third stage of data collecting included asking specialist to indicate the significance of the blockchain adoption barriers in humanitarian supply chain from the second and first stages on a ten-point scale, arranging from "so unimportant" to "so important".

Table 1
Summary of blockchain adoption barriers.

No.	Barriers	References
1	Scalability Issues	[43,44,68], 2- cryptocurrency experts
2	Integrating Problems	[33,42,43,45,46], 1- cryptocurrency experts
3	Lack of Standardization	[43,45,69], 1- humanitarian experts
4	Complexity of Establishing	[45], 2- cryptocurrency experts, 1- DSC experts
5	Regulatory Uncertainty	[33,42,45], 1- academic expert
6	Lack of Knowledge/Employee Training	[49,52,56], 1- DSC experts
7	Market-based Risks	[48–51,70–73], 1- academic experts
8	Technology Risks	[49,53,54], 2- cryptocurrency experts
9	High Sustainability Costs	[53,55,56,74,75], 2- cryptocurrency experts
10	Low/No Transaction Fees	[49,52,56], 1- DSC experts, 1- academic experts
11	Risks of Privacy	[59–63], 2- cryptocurrency experts
12	Usage in Underground Economy	[49,53,76], 2- humanitarian experts
13	Risk of Cyber-Attacks	[64,66,67], 2- cryptocurrency experts
14	Contractual Risk	[8], 1- DSC experts, 1- academic experts

Table 2
Background of expert panel.

Expert No.	Specialty	Work Experience (year)
1	Cryptocurrency	3
2	Cryptocurrency	4
3	Humanitarian Funding	2
4	Humanitarian Funding	6
5	Academic	8
6	Digital Supply Chain	4

Then Best Worst method was used to find out the preferences of each barriers. BWM is also effective in research involving a limited sample size of experts [87]. For instance, past studies have used 12 experts [89], 3 experts [93], and 6 experts [94]. In the subsequent sub-sections, we describe the BWM technique in detail. The methodology structure of research, in Fig. 1, is presented. Thus, we suggested a framework with three stages for studying blockchain adoption barriers in humanitarian supply chain. The stages in this backbone are described in the next parts.

3.1. Fuzzy Delphi method

In the 1950s, Delphi approach was expanded by Helmer and Dalkey [79]. This method is an expert opinion survey technique is with four basic features and characteristics: iteration, and statistical group response, controlled feedback, and anonymous response [80]. The Fuzzy Delphi Method (FDM) is an approach for forming a group communication procedure (which is impressive and effective) by preparing reaction from evaluation of group judgments [81] and information contributions for everybody to re-assess their opinions and judgments. In the majority of actual contexts, specialists' opinion and judgment cannot be exactly clarified into values of quantitative and data of crisp which are not sufficient to create actual systems because of the imprecision, the subjective nature of human thinking, preferences, judgment and vagueness [82]. Based on this method, by Ref. [83] theory of fuzzy set, a pleasant instrument was recommended to overcome the abovementioned problem [84]. The FDM first suggested by Ref. [85] is a mix of Delphi method and fuzzy set theory. These following stages, associated with FDM [84]:

Stage 1: Distinguishing the research-study yardstick and criteria.

Distinguishing the probable obstructions associated to the research. First, the probable yardstick and criteria should be distinguished by means of elaborate review and literature of review.

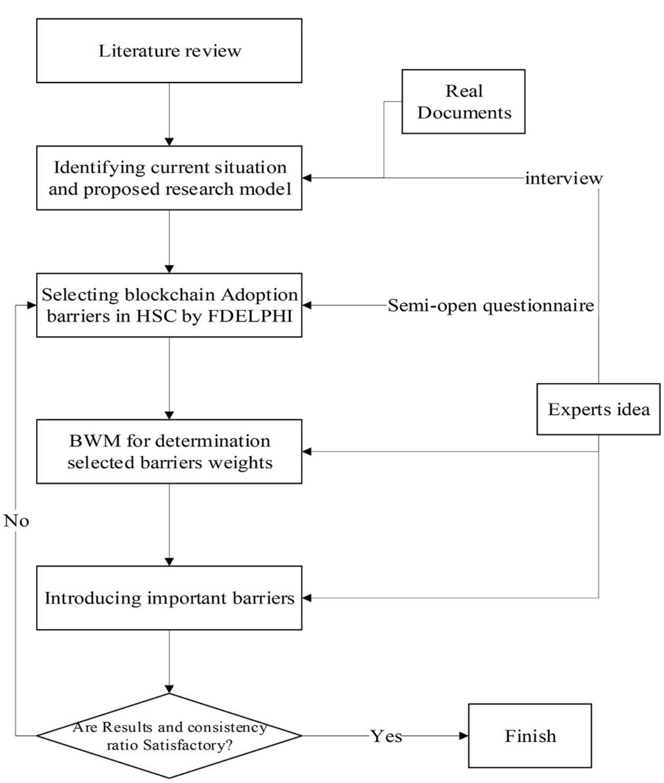

Fig. 1. Research framework.

Stage 2: Gathering specialists' judgements and opinions by applying group decision.

Additionally, after clarifying appropriate criteria performance, relative to the research, an expert is invited to detect the importance of the criteria which was identified, indicated in Table 3, via a questionnaire by applying the linguistic variables. The research employs a mean geometric model for detecting the experts' decision group and assessing the barriers called Triangular Fuzzy Numbers (TFNs).

Stage 3: Identifying criteria

The last stage in the FDM is determining the significant criteria, executed by calculating of each criterion weight with the threshold$\tilde{S}$. By the average of all criteria weight, the $\tilde{S}$ value is compared. Over this way, for each criterion, the (TFNs) τ must be set up, as explained in (1)–(5).

$$\tilde{a}_{ij} = (a_{ij}, b_{ij}, c_{ij}) \quad \text{for } i = 1, \dots, n, \quad j = 1, \dots, m \tag{1}$$

$$\tilde{\tau}_j = (a_j, b_j, c_j) \tag{2}$$

$$a_j = min\{a_{ij}\} \tag{3}$$

$$b_j = \left(\prod_{i=1}^{n} b_{ij}\right)^{\frac{1}{n}} \tag{4}$$

$$c_j = max\{c_{ij}\} \tag{5}$$

In above-mentioned equations, index $i$correlates with the expert and index $j$correlates with the criterion. The note $\tilde{a}_{ij}$ is each criterion fuzzy value, which is gained from every expert, and each criterion fuzzy average value, is $\tilde{\tau}_j$.

In addition, each criterion of fuzzy average value is defuzzified into value crisp, according to:

$$Crisp\ value = \frac{a + b + c}{3} \tag{6}$$

After computing abovementioned values, if the value of crisp $\tilde{\tau}_j \geq \tilde{S}$, after criteria$j$is chosen for following research stage and if the value crisp of $\tilde{\tau}_j < \tilde{S}$, after criteria$j$is refused.

3.2. Best Worst Method

BWM is a comparison-based MCDM method that compares the best criterion with the other criteria, and all the other criteria to the worst criterion. The goal is to find the optimal weights and consistency ratio through a simple linear optimization model constructed by the comparison system [87]. BWM has been applied in vast research area such logistics performance, optimal search model, medical tourism development, research and development, investment opportunities, sustainable oil supply chain management, web service selection, barriers to humanitarian supply chain management etc. [88–91].

Below is a description of the steps of BWM to derive the weight of the criteria [92]:

Table 3
Linguistic scales [86].

Linguistic term	Fuzzy number
Very low (VL)	(0, 0, 0.25)
Low (L)	(0, 0.25, 0.5)
Medium (M)	(0.25, 0.5, 0.75)
High (H)	(0.5, 0.75, 1)
Very high (VH)	(0.75, 1, 1)

1) Determine the set of decision criteria $\{c_1, c_2, \dots, c_n\}$ by decision-makers.
2) Determine the best and the worst criterion to be used for the decision environment:

In this step, decision-makers choose the best and the worst criterion among the set of criteria identified in Step 1 from their perspective. The best criterion represents the most important criterion and the worst criterion is the least important criterion for the decision.

3) Determine the preference of the best criterion over all the other criteria:

A number between 1 and 9 (1: equally important, 9: extremely more important) is used to indicate this value. The resulting Best-to-Others vector would be as $A_B = (a_{B1}, a_{B2}, \dots, a_{Bn})$. Where a_{Bj}indicates the preference of criterion B (best criterion) over criterion j and$a_{BB} = 1$.

4) Determine the preference of each of the other criteria over the worst criterion:

A number between 1 and 9 is assigned in this case as well. The Others-to-Worst vector would be as $A_W = (a_{1W}, a_{2W}, \dots, a_{nW})^T$. Where, a_{jW} indicates the preference of the criterion j over the worst criterion W and a_{WW}.

3.3. Find the optimal weights ($w_1^*, w_2^*, \dots, w_n^*$)

Solving the problem (1) will result in the optimal weights for the criteria. To determine the optimal weights of the criteria, the maximum absolute differences $\{|w_B - a_{Bj}w_j|, |w_j - a_{jw}w_w|\}$ for all j should be minimized.

$$\text{minmax}_j \left\{ \left| \frac{w_B}{w_j} - a_{Bj} \right|, \left| \frac{w_j}{w_w} - a_{jw} \right| \right\} \; s.t \sum_j w_j = 1 \; w_j \geq 0, for\ all\ j \tag{7}$$

By solving this problem, the optimal weights ($w_1^*, w_2^*, \dots, w_n^*$) and the optimal value of $\xi^*$are obtained. In the linear model, ξ^* is defined as the consistency ratio of the comparison system. It means that the closer ξ^* is to a zero value the more consistent the comparison system provided by the decision makers.

4. Findings

As mentioned above, in the second step, the FDM is used to select the identified barriers from the ones listed in the previous step. The output of FDM indicated in Table 4.

According to the expert's opinion and FDM results, the barriers of blockchain adoption in humanitarian supply chains was finalized and is shown in Table 5.

In the last step, the BWM was used to calculate the selected barriers weight to rank them. The expert panel was requested to determine the worst and the best criteria. Afterwards, the decision panel was requested to prepare the priority to the best criterion across other criteria and to afford the priority to other criteria across the worst one. These inputs of the decision panel structured Best-to-Others vector and Others-to-Worst vector that respectively in Table 6 and Table 7 are presented.

The final weights of barriers are determined with a linear model (7) of BWM. By solving this linear model, optimized weights and ξ^* can be obtained for each expert. Then by calculating arithmetic mean of the weights of criteria for each expert, final weights of criteria were obtained. Table 8 and Fig. 2 show the BWM results.

As can be seen from the BWM results, 'Regulatory Uncertainty (C3)', 'Lack of Knowledge/Employee Training (C4)' and 'High Sustainability Costs (C7)' are the most important barriers and, 'Integrating Problems (C2)', 'Risks of Privacy (C8)' and 'Technology Risks (C6)' are the least important barriers respectively. As shown in Table 8, the comparisons show a very high consistency as the value of ξ^* is close to zero.

5. Discussion and conclusion

Blockchain was formerly being utilized for conflict reduction, better land residency and property rights, making safe digital identities, and tackling gender disparity. Therefore, these activities contribute to the plan of the sustainable development objects in innovative paths. There is further a potential in blockchain technology, including possible applications inside the humanitarian supply chain. One of the most exciting

Table 5
Accepted blockchain adoption barriers in humanitarian supply chains.

Index	Barriers
C1	Scalability Issues
C2	Integrating Problems
C3	Regulatory Uncertainty
C4	Lack of Knowledge/Employee Training
C5	Market-based Risks
C6	Technology Risks
C7	High Sustainability Costs
C8	Risks of Privacy
C9	Contractual Risk

Table 4
Result of FDM.

No.	Barriers	L	M	U	Defuzzied	Decision
1	Scalability Issues	0.25	0.75	1	0.666	accept
2	Integrating Problems	0.25	0.72	1	0.657	accept
3	Lack of Standardization	0	0.52	1	0.506	reject
4	Complexity of Establishing	0	0.50	0.75	0.416	reject
5	Regulatory Uncertainty	0.5	0.82	1	0.775	accept
6	Lack of Knowledge/ Employee Training	0.25	0.90	1	0.719	accept
7	Market-based Risks	0.25	0.72	1	0.657	accept
8	Technology Risks	0.25	0.72	1	0.657	accept
9	High Sustainability Costs	0.25	0.65	1	0.635	accept
10	Low/No Transaction Fees	0	0.52	1	0.506	reject
11	Risks of Privacy	0.25	0.72	1	0.657	accept
12	Usage in Underground Economy	0	0.45	1	0.484	reject
13	Risk of Cyber-Attacks	0	0.52	1	0.506	reject
14	Contractual Risk	0.25	0.72	1	0.657	accept

Table 6
Best-to-Others vector.

Expert	Best criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9
Expert1	C4	3	5	5	1	7	4	7	7	5
Expert2	C3	4	5	1	6	5	6	5	6	3
Expert3	C3	4	4	1	6	6	4	3	5	4
Expert4	C7	3	6	2	3	4	7	1	8	5
Expert5	C4	5	6	2	1	5	7	4	8	2
Expert6	C3	4	4	1	7	5	5	6	7	4

Table 7
Others-to-Worst vector.

Expert	Worst Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9
Expert1	C2	4	1	5	6	4	4	6	7	5
Expert2	C8	2	4	6	8	4	6	3	1	4
Expert3	C2	5	1	5	7	6	5	5	7	3
Expert4	C2	4	1	4	5	3	6	4	7	4
Expert5	C8	3	4	5	7	5	4	4	1	5
Expert6	C2	4	1	5	5	6	3	2	4	4

Table 8
Results of BWM.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	ξ^*
Expert1	0.152	0.032	0.091	0.309	0.065	0.114	0.065	0.076	0.091	0.048
Expert2	0.106	0.085	0.291	0.071	0.085	0.106	0.085	0.0258	0.142	0.035
Expert3	0.095	0.031	0.254	0.063	0.191	0.063	0.127	0.095	0.076	0.027
Expert4	0.123	0.038	0.185	0.123	0.092	0.052	0.262	0.046	0.074	0.008
Expert5	0.065	0.054	0.163	0.261	0.108	0.046	0.108	0.027	0.163	0.065
Expert6	0.135	0.042	0.287	0.057	0.135	0.081	0.067	0.057	0.135	0.018
Final weight	0.112	0.047	0.211	0.147	0.112	0.077	0.119	0.054	0.113	0.0335
Rank	6	9	1	2	5	7	3	8	4	

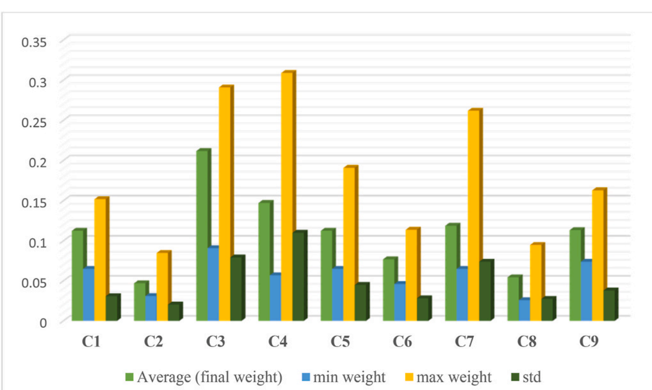

Fig. 2. Summary of BWM results.

overviews is the application of smart contracts to automatize funding via anticipate-based financing. Paired with Big Data analyzing, such models could present for more effective and less political funding tools.

This investigation distinguished the potential barriers to the adoption of the blockchain technology in humanitarian supply chain. The barriers distinguished in this work are apparently transitory in nature because of the oddity of the blockchain technology and as it develops these impediments may be amended [51]. The barriers are also not particular to one utilities of the technology. Along these lines, the goal of this research is to recognize field of blockchain limitation to encourage future academic and professional work in those ways and simultaneously, assist the fulfillment of specialized development. The ideas of trust, chance, protection, security, norms and guidelines are built up territories of research for researchers. These barriers could be areas for future academic study in the novel context of blockchain worth theoretical contributions. Moreover, this work can serve as the incentive for the formation of a universal theoretical model of barriers to the admission of a new technology. In addition, they can present the misunderstandings of the probable adopters similar those to trust, safety, privacy, danger avoidance by innovatively designed blockchain solutions to encourage reception. Practitioners also have to cooperate actively to solicit the required skills and resources and involve the pertinent regulatory bodies to accelerate the standardization of the technology.

The execution of blockchain in the humanitarian supply chain and barriers to successful blockchain accomplishment are presently getting significant managerial and study consideration. Initially, to make this framework, we used the experts opinions and the existing literature on successful blockchain execution. Our research is amongst the implementation of blockchain technology in humanitarian sector apart from cryptocurrencies. We do not assert to be fully inclusive in our review, but the suggested framework is capable of offering a comprehensive collection of barriers that have been plaguing the humanitarian sector. Next, we critically evaluated numerous barriers for blockchain adoption, with the assistance of a strategic valuation method that constructs a framework grounded on BWM and managerial inputs from experts working at humanitarian monetary services, cryptocurrency and digital section, and university. This research was directed to afford a full account of such a complex phenomenon of blockchain adoption barriers in HSCM. Qualitative insights for this study were obtained through an assessment of the open-ended comments provided by 6 Delphi participants. In this study, from 14 barriers only 9 barriers were accepted. This hybrid approach is a novel method that can systematically deal with many uncertain problems with interactive criteria. The most important barriers and challenges were related to the regulatory uncertainty as it is shown in Table 8. The results of the appraisal of the blockchain adoption at humanitarian sector, and inputs provided by their managers helped us to garner some preliminary insights into the significance of these barriers and their sequence. For our study, based on the available experts, challenges in regulatory uncertainty (C3), lack of knowledge/employee training (C4) and high sustainability costs (C7) were the most significant barriers. These findings are interesting because the blockchain ecosystem was conceived to overcome each of these shortcomings present in the incumbent financial instruments and platforms.

5.1. Contribution and managerial implications

The literature review has revealed that HSCs are characterized by a challenging and dynamic stakeholder network coupled with high uncertainty and low transparency in the information and resource flow. The evidence from this study suggests that the information and resource flow in HSC can be improved by either replacing traditional intermediaries or enhancing the transparency and thus lift the information flow and trust between stakeholders. As a consequence, the uncertainty in HSC can be decreased, which results in increased efficiencies in terms of time and costs bu using blockchain. The second perspective has focused on donors, and beneficiaries as the three salient stakeholders in HSCs. Donors benefit from the increased transparency as this empowers them to track the impact of their donations and increases their ability to compare between different NGOs. For beneficiaries, blochcahin offers a new infrastructure to access humanitarian services that are more dignified and empowering.

Thus, decreasing them one by one is essential to carry out a successful blockchain platform in an organization. The key contributions of this study are manyfold. First, the assessment of the barriers to successful blockchain adoption is a decision-making process. The key parts of this study were drawn from peer-reviewed outlets in the information systems and computer science disciplines demonstration of the current state of knowledge. This stage was then applied to develop a framework to evaluate blockchain adoption barriers across humanitarian sectors. Second, the suggested framework can recognize more important barriers amongst these barriers for producing results that allow us to evaluate the various adoption methods and compare the risks among each of them. Additionally, we establish how the derived results could help managers to identify the critical barriers for decision-making, and find the best practices in implementing this technology as well as improve the existing ones.

The humanitarian sector needs research and development to further investigate how blockchain technology can be adapted to address humanitarian challenges. The above use cases are just some of the potential barriers of blockchain technology adoption in the sector. Furthermore, additional research and evidence are needed to translate these potential barriers to actual implementation. Once clear use cases are established in other sectors, the humanitarian sector should adapt best practices and lessons learned from other sectors to translate the blockchain to humanitarian purpose.

Our study has some limitations. We acknowledge that the lack of peer reviewed academic articles and the number of data sources included could be a limitation of the study. Moreover, the theoretical nature of the study could also be voiced as a concern. Nevertheless, we argue that the infancy of the domain, limited sources of reputed data and the lack of theoretical studies on the subject of blockchain adoption barriers in humanitarian supply chain make our research worthy in terms of contribution.

CRediT authorship contribution statement

Iman Ghasemian Sahebi: Conceptualization, Methodology, Resources, Supervision. **Behzad Masoomi:** Formal analysis, Investigation. **Shahryar Ghorbani:** Writing - review & editing, Validation.

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Appendix A. Supplementary data

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