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SPECIAL SECTION ON BLOCKCHAIN TECHNOLOGY: PRINCIPLES AND APPLICATIONS

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Integration of Internet-of-Things With Blockchain Technology to Enhance Humanitarian Logistics Performance

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ABSTRACT There has been incredible interest in Internet-of-Things (IoT) and blockchain technology (BCT) around the world and across sectors. Following great achievement in the other sectors, the implementation of IoT and BCT have gained great interest in Humanitarian Logistics (HL) at many levels despite remaining in an earlier stage. The profit and non-profit organizations both are under increasing worldwide pressure for transparency, with donors and governments calling for enhanced transparency and information exchange in the humanitarian sector. This study, which is based on transactive memory systems (TMS) theory perspectives, proposes a study framework to understand "how can the transparency, public trust, and coordination in HL be improved through the integration of IoT with BCT?". We framed and tested six research hypotheses, using data collected from Humanitarian Organizations (HOs) employees. We have applied a Covariance-based structure equation model (CB-SEM) with confirmatory factor analysis (CFA). This study results confirm that our all hypotheses were supported. The research results show that the association between explanatory variables (i.e., IoT and BCT) and the response variables (i.e., public trust and coordination) is mediated by transparency. This study provides substantial and valid contributions to the literature on IoT, BCT, transparency, public trust and coordination. This study proves that transparency plays a crucial role in enhancing public trust, coordination, and ultimately HL performance through the integration of IoT with BCT. The study results could be helpful for all the stakeholders of disaster risk management since they are insistently looking for strategies to support afflicts. Our study is a good candidate solution to raise awareness of fast, fair, and safe HL to reveal research gaps and provide opportunities for future research. The study will provide an enormous understanding of IoT and BCT in HL, which has not been investigated empirically before.

INDEX TERMS Humanitarian logistics, Internet-of-Things, blockchain technology, transparency.

I. INTRODUCTION

Human suffering has increased recently owing to the increase in both the frequency and magnitude of disasters that are likely to increase more in the future because of climate change [1]. Disasters badly disrupt the working condition of a territory and the functioning of a locality while leading to losses of humane, economic, material, and environment that are outside the ability of populace's capacity by using its very own assets. From 1998 to 2017 due to natural disasters, approximately 1.3 million casualties occurred, individuals affected around 4.4 billion and economic losses occurred nearly 2,908 billion US$ [2], [3]. Furthermore, in 2018, disasters killed 10,373 and affected around 61.7 million people [4] whereas assets losses were nearly 131.7 billion US$. Also, the most vulnerable area was the Asia continent [5]. Likewise, in 2019 worldwide, there were 396 natural disasters recorded, killed about 11,755 individuals, affected 95 million, and assets losses totaled more than 130 billion US$. It indicates that the number of disasters in 2019 was more than

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the average of the last ten years as there were 343 disaster events recorded. As per region, Asia was the most affected continent with 40% of all disaster occurrence, accounting for 45% of the total casualties and another 74% of the population affected by disasters worldwide in 2019 [6]. Between 1970 and 2010, in the South Asian region, 980,000 casualties occurred, whereas more than 2.4 million persons were affected, assets worth of 105 billion US dollars were lost and about 1333 huge disasters occurred [7].

In South Asia, Pakistan is a developing country with an unstable economy and rapidly speedy increasing population, often facing both sudden and slow onset disasters [8]. Pakistan fought four wars with India. Also, the country was the main ally in the war against terrorism, except martyred 6 million security force persons, and casualties occurred around 50 million. Between 2013-2017, 22690 people were martyred in the country in radical attacks [9]. The natural disaster impact in Pakistan can be determined from the fact that from 1993 to 2002 almost 6037 people died and further approximately 8,989,631 were affected [10]. Besides, Pakistan lost from 2010 flooding almost 5.8% of GDP, which was higher than that of the Japanese Tsunami while affecting 2 billion people. In addition, from 2010 onward, flooding has occurred every year in Pakistan [11]. Pakistan has different climate areas including mountains and deserts along with the Arabian Sea. Therefore, between 1971 and 2001 the coastal areas of Pakistan were hit by 14 cyclones. Furthermore, the majority of the area of the country is frequently subject to monsoon rains, humidity storms, cloudburst storms, heatwaves, and drought. Along with flooding, Pakistan is located on an 850-kilometer-long geological fault line that caused frequently diverse intensity of disasters from 1935 to 2015 [11] and onward.

The occurrence of natural and manmade disasters indicates the significance of accurate planning to deal with their effects. Humanitarian logistics (HL) is the primary activity and plays a vital role in the time of disaster. However, humanitarian organizations (HOs) have not so far acknowledged and explained this reality [12]. Moreover, HL always has a low priority in HOs, despite being a factor, which can cause disaster relief operations (DROs) as success or failure [13]. Besides, in humanitarian relief, HL is in the center [14]–[16] in terms of cost and distribution, which is about 80% of total DRO [13], [17], [24]. In addition, nearly 80 percent of logistics cost in DRO is incurred in transportation and procurement [18], [19]. Information sharing in HL removes misunderstanding and forms a balance between stakeholders [20], enhances logistic performance, and reduces uncertainty [21] and information asymmetries between organizations and stakeholders, which further enhance public trust [22], [23].

In the next sections, we introduce the various constructs of the study in the context of HL, the associations between the, and questions of the research.

The literature shows that effectiveness in complex and uncertain situations (such as disasters) is merely possible in the existence of trust [17]. Trust is the most important element for HOs and enables managers to lead and negotiate effectively with multiple stakeholders [25]. Trust is significant for sharing correct information between the stakeholders and HOs on time [26]. As [27] emphasized, trust is mostly applied to decrease vulnerability or uncertainty in exchanges, particularly if actors have limited previous understanding or information [28]. In supply chains (SCs) public trust is a key concept and has been examined from a variety of psychological, economic, and sociological perspectives. Greater trust among SC partners enhances coordination, effectiveness and performance of the chain in both the humanitarian and commercial contexts [29].

Moreover, public trust in organizations can be achieved through transparency [30], [31]. Also, in terms of HL, the start of transparency is public trust. References [32], [33] stated that logistical transparency is an antecedent [34], i.e., a fundamental enabler [26] to public trust, especially when any scandal occurs [34], and also plays a key role in connecting and forming relationships between victims and organizations [26]. Similarly, transparency enhances public trust and understanding [35] while without trust, transparency is not sufficient [32]. Reference [36] found that greater transparency can empower the decision-makers to take better quality of decisions, which further leads to public trust. As a result of better decision-making through transparency, if the people perceive them as such, certainly, the people may admit the decision and show trust to the decision-makers. Furthermore, the integration of IoT with BCT [37] allows actors for transparency and confidential data sharing, and thus enhances public trust among players of DRO [38], [39]. Nevertheless, research into the mediating role of transparency between the integration of IoT with BCT and public trust is in its early stage. In conclusion, knowledge of the impacts and relationship of IoT and blockchain on transparency and public trust remains unexplored and there is a lack of theoretical background. Therefore, the first research question of the study is: what are the specific and joint effects of IoT and BCT and transparency on public trust?

In general, along with other reasons behind the barriers in the way of greater coordination in humanitarian settings are poor positioning of the application of information technology (IT) [40], lack of transparency and trust among actors [4]. Helping people during this difficult time of disaster needs instant action that is facilitated by coordination among multiple involved players, such as agencies of local people, state and federal government, faith-based organizations, private-based firms (local grocers), non-governmental organizations (NGO) [41], donors, the local communities, HOs, the military and both local and extra regional HL services providers (HLSP) [42]. Transparency is the key to coordination in logistics and leads to organizational efficiency and effectiveness, which in turn increases capital in terms of commercial organizations and survivors in terms of HOs. Moreover, coordination among relief players in the disaster-prone area can create benefits like access to further resources, (i.e. donated funds, technology and information) that further enhance HL performance [4]. In operation management, field coordination is a crucial component and has a positive impact on organizational performance [43], leads to competitive benefits, reduces costs, enhances service levels and response quickly to uncertain, complex and changing circumstances [44]. In HL, successful coordination depends on the commitment of the actors involved in the DRO. Also, [4], [45], [46] stated that coordination requires transparency and disclosure of data in SC. Still, except unreliable indications, the current literature has remained quiet on the role of the integration of IoT with BCT in the very important concept of HL, even though it allows players to share data transparently and securely. This study focuses on transparency and public trust as antecedents of coordination. Scholars have indicated that transparency and public trust may greatly affect firm HL process characteristics [4], [17]. Nevertheless, such vital impacts have not been addressed by scholars either theoretically or empirically. However, the extant literature provides some evidence [4], [37], [47] that the integration of IoT with BCT can bring positive changes, not only in organizational cultures and S but also in the industry as a whole. Therefore, we note a wide research gap and henceforth postulate another research question: what are the specific and joint influences of the integration of IoT with BCT on coordination mediated by transparency? This question is very interesting to be more thoroughly investigated.

Besides these research questions, the primary objective of the article is to offer a complete picture of the need for fast, fair, and safe HL and how it can be reached. More precisely, this research aims to address the question; ''How the performance of HL can be enhanced through the integration of IoT with BCT''. Moreover, the state of the present literature on BCT and IoT does not specifically explain how the constructs can be conceptualized, how it appropriate to managing transparency, public trust and coordination in terms of HL. Hence, the research has three objectives. (i), the literature on IoT and BCT is incorporated crossways academic disciplines to cover a complete understanding of the integration of IoT with BCT. (ii), the actual uses of the integration of IoT with BCT mediated by transparency are examined. (iii), the importance of those elements in impacting the performance of HL is explored. To fulfil the study objectives, and to answer our research questions, we applied data, gathered from 337 practitioners of HOs belonging to various job functions including, chief executive officers, managers, supervisors, logisticians and field officers engaged in DRO. Furthermore, to offer theoretical justifications to interpret this study's empirical results, we applied TMS theory [48], [49] because along with IT the theory also enlightens the direct or mediating roles of transparency, trust and coordination for personal and group performance and competitive advantages. Also, this article adopts a CB-SEM on the basis of CFA with SmartPLS software was applied. The research argues that HL performance can be possible through coordination, public trust and transparency, whereas coordination, public trust and transparency occurs through the integration of IoT with BCT. Similarly, this research findings show that the integration of BCT with IoT enhances performance through transparency, public trust and coordination. Moreover, the findings contribute to the present literature in HL and cover the way for further advancement in DRO. As to date, the current research has only concluded that BCT positively affects coordination. Our study will reveal research gaps for future pertinent research to develop more effective HL operations.

The rest of this paper is structured as follows. The development of the theoretical model and hypotheses is presented in Section II. Subsequently, Section III describes the research method of the study, and the data analyses are presented in Section IV. The study results are discussed, and the contributions to theory and practice and future works are presented out in Section V. Finally, Section VI offers the study conclusions.

II. THEORETICAL MODEL AND HYPOTHESES DEVELOPMENT

The basis of this study's theoretical model is grounded in transactive memory systems (TMS) theory perspectives [48], [49] because the theory covers not only IT but also transparency, trust, and coordination for personal and group performance and competitive advantages. TMS is a group level cognition theory, which describes how people in a group learn, collect, apply and coordinate their information to achieve personal, group or organizational goals [50]. Besides, this theory, describes a joint system that people in interrelationships practice to encode, store, and retrieve information [49]–[51]. Reference [49] stated that TMS theory borrows mostly from what is well-known regarding the memory developments of people and applies it to groups. Moreover, this theory can be considered in personal memory systems and the transformation of information among them. Those people who are part of a TMS presume responsibility for various information domains and trust each other to reach the expertise of each other across domains. Therefore, the TMS theory is very relevant in the present study context as it appeared as an influential description of how information is applied successfully to gain competitive advantage, particularly in a highly uncertain environment [50]. In a similar context, research has considered the association between transparency, trust and coordination and its impacts on firm performance [34], [52], [53]. The theory makes a strong connection between IT with transparency, trust, and coordination, and also in the past two decades, scholars from multiple fields including management, have focused on the concept and its impact in groups and organizations [50], [51].

IT enhances performance through information sharing and coordination among the players in humanitarian settings [26]. As in the Katrina disaster, ham radio played a crucial role not only in information transmission but also in the coordination among ambulances dispatchers, operators, and logisticians [50]. Transparency makes it easier for interested stakeholders to access and understand the situation in

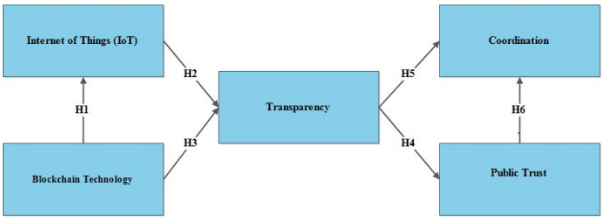

FIGURE 1. Theoretical framework.

the organization. If the HL process is not transparent, its stakeholders may learn very little regarding the organization. Therefore, interested stakeholders with great learning will be concerned regarding its transparency. Hence, they will trust and prefer more transparent HOs if other processes are similar [54]. Hence, it can be argued that information sharing can help to increase public trust in organizations [17]. Similarly, based on TMS theory, transparency and public trust among the actors engaged in DRO play a crucial role in increasing coordination in HL [50]. In terms of technology, [55] reported that the application of advance technology systems can enhance the transparency, trust and coordination among actors involved in HL. Therefore, the study's theoretical model can be proposed informed by an organizational perspectives TMS theory

A. INTERNET-OF-THINGS AND BLOCKCHAIN TECHNOLOGY

IoT is a new worldwide internet-based information planning technique for easing goods and services exchange processes. Although there is no exact definition of IoT, it is argued that the IoT may work for universal computing, enabling smart situations to identify objects and recover information from the internet to help their adaptive functionality [56].

The IoT enables many devices to keep continuously connected to the network and communicate information uninterruptedly [57]. In this method, it controls different variables and deviations, minimizes risks through steady interaction and inter-connection of tangible and intangible devices [58]. The centralized server is the key to IoT systems, which control information created by these devices. The IoT devices consist of computers, smartphones, and remote-control equipment. On the other hand, a centralized server allows information to be tampered with. Hence, a centralized system decreases data reliability and further creates huge security problems [59]. IoT in HL will be able to fully resolve the problem of quality and security of relief items. Additionally, the best possible way to control issues of data reliability and security problems is the incorporation of IoT with BCT [37].

As the IoT is surrounded by many technologies, a sole reference architecture is not appropriate as a blueprint for all concrete implementations [56]. Currently, the interest in bitcoin is enhanced, and the use of BCT that influences the crypto currency notion and gives the primary technology has gained keen interest among researchers, policymakers, and practitioners [60], [61]. Blockchain is a system that brings together different people and firms that do not completely trust each other; nevertheless, they are striving toward a common goal [62]. Normally, BCT enables safe transactions among actors of SC through a digital ledger that may not be tampered with [63]. In the business world, numerous organizations, including Maersk and Walmart, have deployed BCT [64], [65]. BCT can generate trust among multiple parties, coordinate among different actors, manage resources, demonstrate authenticity and proprietorship, save time, overcome data security challenges, increase transparency and enhance HL performance [37], [66]. There are two basic dimensions in the blockchain: (i) Transactions as a whole are made by the operators of the system and (ii), in the blocks transactions are saved in the exact order [67]. In addition, some researchers [68]–[70] stated that BCT has such a great potential to form HL operation, whereas the implementation of BCT in relief operations is in its infancy.

The incorporation of IoT devices with BCT can permit the collection of information in a decentralized manner, allowing large data centers at low costs [67]. In HL, the application of blockchain and IoT indicates site, reporting, self-correcting, inter-operability, digitization, data standards, inter-connectivity, universal scaling and applies intelligence, improves speed, security and transparency, information regarding warehouses, trucks, and cargo, new order placement and ensures the distribution of relief items to the needed afflicts. Therefore, it can be argued that blockchain through IoT can lead to fast, fair, and safe HL [37] and can be magnificently utilized for enhancing IoT. Consequently, we hypothesize as H1: BCT is positively associated to IoT.

B. INTERNET-OF-THINGS AND TRANSPARENCY

The IoT creates a wide range of possibilities for correcting inaccurate activities by maintaining a constant ledger of transactions accessible for all players involved in DRO. Moreover, the IoT has the capability to link several devices to the network and transfer information without disruption [37], [57]. Thus, a stable communication with the environment is created in order to overcome various variables while decreasing risks and controlling possible nonconformities [58]. Moreover, the IoT enables online visibility of information; therefore, all HL activities are monitored and controlled as per rules and regulation [37]. Thus, it can be argued that IoT has the potential to enhance greater transparency. Transparency within the different actors engaged in the HL process is crucial for performance in DRO [16], [17]. Reference [22], [23] reported that transparency reduces information asymmetries between organizations and stakeholders when supported by disclosure theory and signaling theory. IoT plays a key role in enhancing logistics transparency [71]. Thus, the role of IoT is hypothesized as H2: IoT is significantly associated to transparency.

C. BLOCKCHAIN TECHNOLOGY AND TRANSPARENCY

Despite growing research on transparency, the concept has not yet been adequately explained. Reference [72] defined transparency as the internal real organizational information being shared externally with stakeholders. Similarly, [32] stated that transparency is not only about sharing the positive aspects of the organization but also the way for gaining improvements. This suggests that transparency requires producing, fostering, and maintaining distributed communication and dialogue with stakeholders. Reference [73] stated that a lack of clear and unreliable information among actors involved in HL is mostly considered the main obstacle in coordination among these actors. Currently, in the presence of big data, information sharing performs a key role in HL performance [4]. Furthermore, [37] argued that BCT is explicitly suitable for tracing information and offering its visibility to actors involved to offer online replies to bring modification in order. In addition, [74] claimed that BCT can help to overcome problems that hamper information sharing by providing information that is available to users as a whole while ensuring data security. This reduces the cost and enhances transparency in HL information [4]. Therefore, owing to BCT, it is easy for various HLSP involved in DRO to gather and share information on the similar system. Henceforth, it can be argued that BCT provides a permanent, searchable, finally unchangeable, and reliable public records repository. So, the resulting hypothesis is postulated as H3: BCT is positively correlated to transparency.

D. TRANSPARENCY AND PUBLIC TRUST

References [32], [33] found that logistic transparency is an antecedent to public trust, especially when any scandal occurs [34]. In addition, [30], [31], [34] reported that the only way to accomplish the goal of higher trust is transparency. Similarly, [75] stated that HOs can sustain and build trust through information sharing with stakeholders as its roots in disclosure and signaling theories [22], [23], [34], [76], [77]. Disclosure reveals the intent of HOs to establish honest and proper principles related to sharing of information and openness, which indicate the honesty of the organization and further build trust and ultimately performance [34], [77]. Disclosing is by itself a decision to do the right-thing instead of hiding the information to get unfair benefits by management in HL. Therefore, it can be stated that greater transparency can help to increase public trust among the actors involved in DRO, and also the beginning of transparency is trust; hence HOs need to be transparent [17]. Contrarily, if HOs are not performing as expecting by donors, they may stop funding [78]. Reference [79] indicated that transparency is a safeguard against switch dependence and encourages stakeholders to be involved actively in the process of decision-making. Hence, it can be argued that transparency reduces the unfair gain of the actors involved in DRO, decreases uncertainties and increases public trust. Thus, we posit the following hypothesis. H4: Transparency has a positive relationship with public trust.

E. TRANSPARENCY AND COORDINATION

Coordination is found an opportunity by emergent response group through learning by doing [50]. It's more important than ever and requires a high level of transparency especially in HL [80]. In the old maxim, the challenge in coordination is "everyone wants coordination nevertheless nobody wants to be coordinated" [81]. Several researchers have described the importance of coordination and also reported that this is an area that needs immediate and profound consideration [55], [82]. Therefore, coordination in the context of HL has gained enormous attention from researchers [41], [55], [83]. In response to a disaster, it is not possible for a single organization to cover multiple needs and wants, whereas a lack of performance of the HL may occur due to lack of coordination among organizations [55]. They further argued that despite other barriers to coordination in humanitarian settings, there is a lack of transparency [55]. Also, [84] reported that transparency and improved coordination alongside logistics is a common theme, and guarantees decreased vulnerabilities, allowing the actors involved in logistics processes to deal with growing threats without sacrificing efficiency.

Reference [85] stated that the coexistence of cooperation leads to coordination. Coexistence involves the sharing of the minimum necessary information among actors involved in humanitarian settings. Therefore, it can be argued that transparency leads to coordination. Policy makers require reliable, accurate, and timely information for well-coordinated system networks for dynamic environment response [86] as its roots in TMS theory. This theory explains how individuals in interrelationships, groups, and organizations learn who knows what and apply that information to decide who will do what, thereby increasing efficient and effective personal and group performance [50]. Furthermore, coordination among HLSP has been acknowledged for an effective logistics response following a disaster. Importantly, coordination is essential for long-term HL performance. Consequently, we argue that based on TMS theory, HL performance can be improved through coordination among stakeholders, whereas coordination can be enhanced through transparency [49]–[51]. Similarly, [87] reported that dependence creates various kinds of HLSP coordination, whereas coordination can be reinforced through greater transparency. Hence, it can be argued that based on dependence theory, coordination can be increased through transparency. Thus, our next hypothesis can be written as H5: Transparency is positively associated with collaboration.

F. PUBLIC TRUST AND COORDINATION

Reference [88] stated that collaboration is a shared creation of a process, product, or event through exchange of complementary skills among different people, units and/or organizations, whereas without coordination there will be overlapping, redundancy, and separation. Forming trust is not the completion by itself. From organization theory, coordination of the organization can be effective through mutual trust [29], [89], [90]. Therefore, it is vital to examine the influence of coordination on public trust in humanitarian settings. On the other hand, [29] stated that coordination in HL arises from the task interdependencies, whereas a sole firm may not be capable of fulfilling the requirements of the victims in the disaster-prone area as its roots in coordination theory. Reference [91] stated that different coordination techniques, ranging from central planning to marketplace, are achievable, where there is a multiplicity of involved actors. In this context, [29] stated that as the central approach of DRO, the cluster method may be seen as a method of group decision-making. It allocates a sole lead organization (umbrella organization) as the controller to help coordination in HL [29]. There is no formal membership in the cluster approach in DRO. Many HOs retain a significant level of independence and interface with the group merely when they need it [38]. To motivate HOs for coordination in humanitarian settings, trust is the main element to help coordination, whereas the lack of trust is a key hurdle in the way of coordination among organizations [55]. References [26], [29], [92], [93] found a significant relation between trust and coordination among players involved in DRO. Therefore, in line with organization and coordination theories, it can be argued that coordination can be established through trust and, also, that forming trust is vital for effective inter organizational coordination. So, we present the following hypothesis. H6: Public trust has a positive relationship with coordination.

III. RESEARCH METHOD

A. SURVEY INSTRUMENT DEVELOPMENT

On the basis of the previous assumptions, we used an online questionnaire created in Google drive, to test the reliability, validity, model fit, and psychometrical accuracy of the study framework. The research framework included two dependents, a mediate, and two independent variables. The construct of IoT was measured by four items adopted from [26]. BCT was measured by five items adopted from [4]. Transparency was measured by five items adopted from [4], [33], [72]. Public Trust was measured by five items adopted from [4], [26]. Coordination was measured by six items adopted from [29]. Altogether, the questionnaire had 26 items that were rated by respondents on a five-point Likert scale (a score of 1 represents "Never, Strongly disagree, not probable and very untrue of what I believe," whereas a score of 5 denotes "Always, Strongly agree, very probable and very true of what I believe". The items were formed as a whole on the basis of present measurements and studies in English language. Very small changes were made as appropriate in the present context. After the questionnaire was drafted, it was reviewed by some experts (professor and managers) from the relevant field. Based on their comments the questionnaire was modified to indicate correctly the context of IT in HL. After a pilot test, small changes were made to the questionnaire to make it ready for data collection.

B. SAMPLE AND PROCEDURE

To test the study hypotheses, the primary data were collected from HOs involved in DRO in Pakistan. Similarly, data were collected from employees belonging to various job functions (e.g., chief executive officers, managers, supervisors, logisticians, and field officers) in HOs. We identified the basic informants with the help of the https://reliefweb.int/organizations and https://pakngos.com.pk/ngos databases. The contact information of all HOs was gathered through these databases. Furthermore, some HOs personnel were contacted through different social networks such as face book messenger, LinkedIn etc. The study respondents included employees from those HOs, using artificial intelligence, IoT, BCT and big data analytics in DRO or those who are planning to be adopted in near future. Also, when the demographic section of the questionnaire confirmed that they do not use these technologies or are planning to adopt them, then their responses were excluded.

C. DATA COLLECTION

The study adopted the tailor designed method for data collection [94] as researchers have recently adopted the method for improving the response rate [4]. The data were collected from April to September 2020. We contacted 1959 HOs respondents via emails, Facebook and LinkedIn by sending a cover letter which explained the survey purpose and with an assurance to each respondent about their information anonymity and confidentially. After three reminders via email 337 useable responses were received, giving a response rate of 17%. Even the response rate is low. Although this is in line with other works such as 15% [4] or 13% [95], the lower response rate is likely due to the fact that the respondents were HOs and mostly yet to know how to use IoT with BCT in humanitarian context. Also, there is little consensus on the recommended sample size for the structure equation model (SEM). As the critical sample size is 200, any number more than 200 is recognized to give suitable statistical power for data examination [96], [97]. The study respondents were chief executive officers, managers, supervisors, and field officers. The main service activities of the respondents' HOs were health, logistics, food security, water, sanitation and hygiene and camp coordination. Followed the study of [98], bias response has been compared with earlier responses (first and last 30%) and late respondents have been assumed to be similar to non-respondents [98]. The study found that non-statistical dissimilarity for each item $p>0.25$ is observed for all measurement items. Therefore, non-response bias was not a major concern in this study.

D. DATA ANALYSIS

In statistical application, no method can be considered good or bad but it is vital to well understand the method that can be used. Reference [99] stated that the preferred method is covariance-based SEM (CB-SEM) instead of partial least-square SEM (PLS-SEM) in the primary social sciences, whereas after 2010 most researchers have used PLS-SEM [100]. Regardless of some characteristics, the PLS technique does not deal with factors and does not account for measurement error, which further leads to biased parameters. In contrast, CB-SEM shares statistical reliability [101] and is used for validation of the existing theory [102]. The application of GoF is only possible in CB-SEM which minimizes the residuals variation between the observed and latent variables [103]. Generally, PLS-SEM is a good statistical method for formative models and predictive analysis, whereas CB-SEM provides accurate results for reflective models and if the research purpose is confirmatory modeling. Moreover, CB-SEM is based on confirmatory factor analysis (CFA) and PLS-SEM on PCA [104]. As CFA provides correct results in the analysis of the basic hypothetical process or construct, it can be used to examine correlations among variables and the structure of the data. On the other hand, if there are fewer variables to be summarized, principal component analysis (PCA) is the preferred choice [105]. Reference [106] stated that the results from CFA and PCA were generally similar and that there is no basis to recommend one of the other as being more suitable. Every method has some pros and cons but these are beyond the scope of the research. Based on the existing literature as the research model is reflective, we therefore used CB-SEM on the basis of CFA with Smart PLS3 package [99].

For formative constructs, a multiple indicators and multiple causes (MIMIC) model may be used to assess the external and internal validity [107]. In contrast, for reflective constructs, different measures can be used for reliability and validity [104]. Similarly, various techniques were applied to evaluate the items' reliability, validity, model fit and psychometrical soundness. Cronbach's alpha & the composite reliability (CR) were used for testing reliability. For measuring convergent validity, factor loading and average variance extracted were used. For discriminant validity, the Fornell–Larcker criterion and Heterotrait-Monotrait Ratio (HTMT) were applied. SRMR, NFI and d_ULS, d_G and Chi-Square were used for assessing goodness of fit (GoF). For predictive validity, normality and multicollinearity, (Q2) r Stone–Geisser indicator, Skewness, Kurtosis and variance inflation factor (VIF) were applied, respectively. Later, for evaluating the psychometrical soundness of the research framework, T-Test was used. Finally, various robustness tests were applied for measuring the validity of the results. The CB-SEM method contains five constructs and 26 indicators

E. DESCRIPTIVE STATISTICS

The data were controlled through gender, age, qualification, experiences, function, and position and were evaluated after checking for normality. All questionnaire procedures, instructions, directives, and exercises were conducted in Pakistan. Participants were 337 HO professionals, including chief executive officers (5.3%), managers (19.6%), supervisors (17.8%), logisticians (13.1%) and field officers (31.2%). A total of 88.1% were male and a plurality (45.2%) were aged from 25 to 34 years. A total of 68.8% and 24.3% were postgraduate degree holders and were involved in logistics service, respectively. Mean, Std. Deviation, Variance, Skewness, and Kurtosis were also identified.

TABLE 1. Adjustment quality for the SEM model.

	Mean	SD	Ske.	Kur.	Tol.	VIF
IoT	3.116	1.365	-0.016	-1.176	.707	1.414
BCT	3.878	0.861	-1.029	1.617	.584	1.712
Transparency	4.034	1.07	-0.993	0.335	.524	1.909
Public Trust	3.872	1.160	-0.734	-0.496	.784	1.275
Coordination	3.878	0.943	-0.879	0.678		

TABLE 2. Adjustment quality for the SEM model.

	R2	AR2	CA	CR	AVE
BCT			0.81	0.87	0.57
Coordination	0.41	0.41	0.87	0.91	0.62
IoT	0.36	0.37	0.77	0.84	0.52
Public Trust	0.37	0.37	0.76	0.84	0.51
Transparency	0.60	0.60	0.77	0.85	0.52

Note: CA, Cronbach's Alpha; CR, Composite Reliability; AVE, Average Variance Extracted.

IV. RESULTS AND ANALYSIS

A two-step CFA/SEM approach was applied for the study model [99]. Some assumptions like normality and multicollinearity were examined before using Smart PLS 3. For checking the normality of the data, skewness & kurtosis were applied in SPSS. Table 1 revels the values of mean, standard deviation (SD), and normality of the variables. The data were normal as the results of skewness were under the accepted range of ±2 [108]. VIF was performed for checking multicollinearity as the tolerances for all the explanatory variables were very close to 1 and all VIF values were $<$ 3 (see Table 1). It indicates that multicollinearity was not an issue for further concern [109], and [110] even suggested a more lenient threshold of 10.0 for VIF.

A. COMMON METHOD BIAS (CMB)

As data collected through a single source can lead to CMB that might threaten the validity of the study [111], Harmon's one-factor test was used to examine if CMB caused any problem. The result revealed five factors with eigenvalues more than 1, of which the first elucidated merely 40.734%. As this was far less than 50%, therefore, it can be concluded that there is no threat of CMB [111].

B. ASSESSMENT OF MEASUREMENT MODEL

Adjusted and Unadjusted R square: Pearson's coefficient R Square (R2) was measured to evaluate the mediating and response variables' variances. In this research, R2 and adjusted R2 values were almost similar at 0.36, 0.60, 0.37, and 0.41 for IoT, transparency, public trust, and coordination, respectively, as seen in Table 1. Thus, the values showed a large effect size and a well-fitted model [112].

Reliability of the Measurement Model: Cronbach's alpha evaluates the internal consistency reliability of the constructs, while CR is a more lenient reliability measure. For both

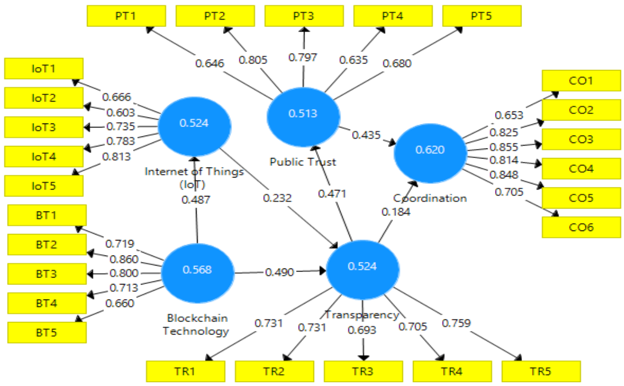

FIGURE 2. Convergent validity according to AVE values.

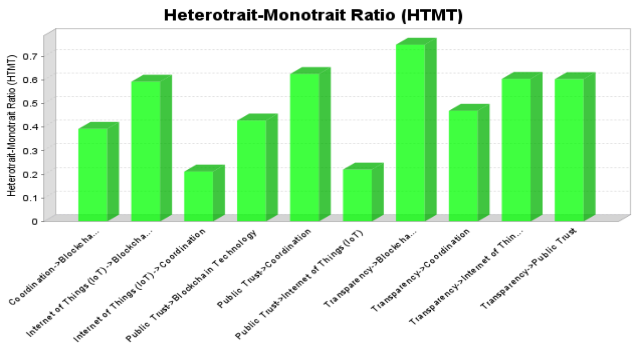

FIGURE 3. Discriminant validity analysis through HTMT.

Cronbach's alpha and CR, the threshold value is 0.70. As seen in Table 2, the values of the constructs were greater than the recommended value of 0.70, which thereby showed a well-fitted model based on Cronbach's alpha and CR and revealed high reliability [113]–[115].

Validity of the Measurement Model: A construct cannot be reliable without validity [116]. Therefore, validity (convergence and discriminant) tests were applied in this study. The factor loading values were more than the cutoff value of 0.70, and values of AVE for all variables were above 0.50 [114], indicating no problem with convergent validity, as seen in Table 2 and Figure 2.

Besides, the framework was measured by discriminant validity, which can be applied if a latent variable accounts for higher variance in its relevant observed variables than it shares with other variables in the similar model [117]. However, the recommended measure for discriminant validity is HTMT [118]. The HTMT values were less than the cutoff value of $\leq$ 0.85 [115] for all constructs, which assures discriminant validly as shown in Figure 3.

C. CORRELATION

Pearson Correlation analysis was conducted in SPSS as it offers early support to the research hypotheses. The results showed a positive significant association between all constructs as seen in Table 4.

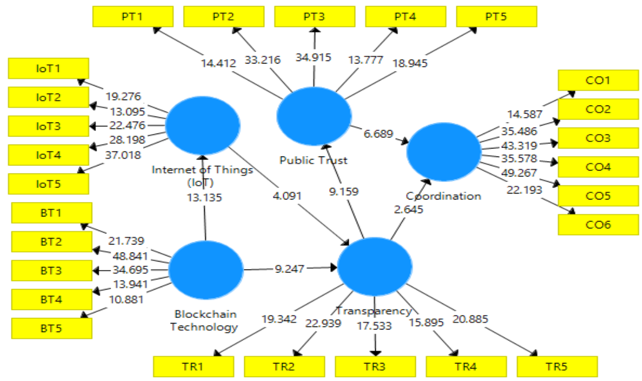

FIGURE 4. Structural model.

TABLE 3. Discriminant validity with the fornell-larcker criterion.

	BCT	Coordination	IoT	Public Trust	Transparency
BCT	0.75				
Coordination	0.33	0.79			
IoT	0.49	0.17	0.72		
Public Trust	0.33	0.52	0.16	0.72	
Transparency	0.60	0.39	0.47	0.47	0.72

The model fit of CB-SEM was measured for causal model and for testing the study hypotheses. As per the study framework, multiple fit indexes were applied through Smart PLS. The results indicated a well-fitted model, as seen in Table 5, as the value of SRMR of 0.07 demonstrated a well-fitted model because the value was <0.08 [119]. The values ofd_ULS1.94 and d_G0.56, indicated a well-fitted model because the value is lower than the estimated values [120]. Furthermore, the value of Chi-Square 1045.41 was lower, and the value of NFI 0.74, which was similar to the estimated values and further showed that the model was a good fit [110], [119], [121].

As observed in Table 6 and Figure 3, the results indicated that BCT had a significant positive influence on IoT (T 13.14, P 0.00). Thus, H1 was supported. BCT had a significant positive influence on transparency (T 9.25, P 0.00), which supported H2. IoT had a significant influence on transparency (T 4.09, P 0.00) and supported H3. Public trust had a highly positive effect on coordination (T 6.69 P 0.00), which supported H4. Transparency had a significant positive impact on coordination (T 2.65, P 0.01), which supported H5. Transparency had a significant positive influence on public trust (T 9.16, P 0.00), which supported H6.

D. ROBUSTNESS TESTS

Various robustness tests were conducted in order to ensure the results' validity. A separate model was verified for control variables, which produced a well-fitted model. To identify further valid insights, linear regression examination was conducted in SPSS, as seen in Table 7. The results exhibited a well-fitted model. Besides, there was significant similarity between the SEM and regression analysis results. Hence,

TABLE 4. Discriminant validity with the fornell-larcker criterion.

		1	2	3	4	5
IOT	P. Corr.	1	.479**	.476**	.156**	.173**
	Sig. (2-tailed)		.000	.000	.004	.001
	N	337	337	337	337	337
BCT	P. Corr.	.479**	1	.600**	.332**	.324**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	337	337	337	337	337
Transparency	P. Corr.	.476**	.600**	1	.449**	.379**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	337	337	337	337	337
Public Trust	P. Corr.	.156**	.332**	.449**	1	.505**
	Sig. (2-tailed)	.004	.000	.000		.000
	N	337	337	337	337	337
Coordination	P. Corr.	.173**	.324**	.379**	.505**	1
	Sig. (2-tailed)	.001	.000	.000	.000	
	N	337	337	337	337	337

TABLE 5. Fit summary.

	Saturated Model	Estimated Model
SRMR	0.07	0.08
d_ULS	1.94	2.08
d_G	0.56	0.56
Chi-Square	1045.41	1051.13
NFI	0.74	0.74

the robustness tests affirmed the validity of the present study model.

V. DISCUSSION

There are some rational arguments behind the integration of IoT with BCT to enhance performance in the context of transparency, public trust, and coordination. The implications of these constructs may differ between business organizations and HOs. Humanitarianism scope is not only limited to the deployment of resources among victims but also to ensure human rights development and peace building, and is extensively based on proper management of relief items [30].

TABLE 6. Hypothesis testing.

	ORIGINAL SAMPLE (O)	SAMPLE MEAN (M)	STDEV	T STATISTICS	P VALUES
BCT -> IoT	0.49	0.49	0.04	13.14	0.00
BCT -> Transparency	0.49	0.49	0.05	9.25	0.00
IoT-> Transparency	0.23	0.24	0.06	4.09	0.00
Public Trust-> Coordination	0.44	0.44	0.07	6.69	0.00
Transparency-> Coordination	0.18	0.19	0.07	2.65	0.01
Transparency-> Public Trust	0.47	0.47	0.05	9.16	0.00

TABLE 7. Regression results.

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
1 (Constant)	2.123	.167		12.684	.000
Public Trust	.453	.042	.505	10.721	.000
2 (Constant)	1.683	.203		8.285	.000
Public Trust	.376	.046	.420	8.105	.000
Transparency	.183	.050	.191	3.691	.000

In IT, the integration of IoT devices with BCT provides a golden opportunity to overcome many of the flaws, resulting from lack of information or uncertain information in HL processes. The non-exiting of research on the topic indicated an urgent need for enhancement of HL performance. Therefore, this study aimed to extend the unique empirical research from a different perspective, i.e., the enhancement of HL performance through the incorporation of IoT devices with BCT.

Along with overcoming the issue of security, IoT with the integration of BCT enhances transparency, trust, and coordination among the partners in SC, which further enhances performance. This research developed the explanation of the technology, positioning from TMS theory perspective, and confirmed that secure transaction in the whole SC is not only a challenge but also an opportunity. The theory also covers transparency, trust, and coordination in terms of HL. In humanitarian settings, data sharing and transparency constantly remained a critical challenge. To decrease the disruption of data sharing and to increase transparency in HL, HOs need infrastructure and processes that can allow the exchange of information without any disruption among all the actors engaged in DRO [4]. Henceforth, the information exchange through enhanced data processing capacity with no fear of information distortion may decrease behavioral uncertainty, specifically if a logistician team is swiftly formed and if the situation in which the logisticians and operational tasks are greatly complex. In addition, HL is not the same as commercial logistics but is unique due to various types of disaster (natural or manmade), speed of disasters (slow onset or sudden onset), and phases of disasters (mitigation, preparation, response, and rehabilitation). In order to improve performance in HL, transparency, public trust and coordination play a crucial role to optimize logistics flows, while also connecting multiple actors belonging to different cultures involved in DRO [71]. Therefore, through the existing literature, it was considered that the integration of IoT with BCT, as fitting to the special case of data processing proficiencies, will be facilitated by current developments in technologies that are rooted in organizational processes. Consequently, the present study examined the relationship between the integration of IoT with BCT and its influence on transparency and their effect on public trust and coordination among the players involved in DRO. To address this, the study hypothesized the first study question. The research statistical results validated the present strands of theory concerning the different and combined influence of IoT, BCT and transparency on public trust [50]. Therefore, this study provides an important contribution to the literature as scholars have loudly called for quantitative justification of technologies, transparency and trust in the context of HL [38], [39].

Next, the study further investigated the association orientation (IoT, empowered transparency, and coordination) as an informal governance between players involved in DRO. Similarly, the research results further supported the need for the integration of IoT with BCT for coordination mediated by transparency and ultimately for HL performance [4], [17]. To examine this concern, this study postulated the second research question. The empirical results validated the association between transparency and coordination, which supports previous literature [4], [45], [46] findings. Additionally, these study results were completely consistent with previous disclosure and signaling theories [22], [23], [34], [76], [77]. Further, informed by existing studies [87], this research examined the impact of technology and public trust on coordination based on TMS theory [86]. The studies of [41], [55], [83] indicate a rich literature on trust and coordination. Little is known about the combined effects of technology, transparency and trust on coordination. Hence, the study findings validated that the integration of IoT with BCT, transparency and public trust are significant predictors of coordination. Consequently, it can be argued that these study findings offer a unique insight to the literature that has either investigated the association between transparency and trust or trust and coordination. Also, prior theoretical propositions statistically confirmation was a huge research gap. So, this study has confirmed that transparency and public trust have a significant impact on coordination. Furthermore, these study results are aligned with the interrelation view of [49]–[51], [87]. Table 6 and figure 3 summarize the evidence of information offer in supporting of the research hypotheses postulated in this study. Collectively, the results of this study have practical implications and theoretical contribution in HL.

A. THEORETICAL CONTRIBUTION

As per these study results, it can be argued that these study results provide some useful insights into theory. First, there is agreement that IoT plays a key role in enhancing logistics transparency [71]. To date, little has been identified regarding how IoT can enhance transparency. Hence, this study found empirically not only a strong and positive connection between IoT and transparency but also between BCT and transparency. Hence, based on this study, it can be argued that the integration of IoT with BCT can exert a strongly positive effect on transparency as its roots in disclosure and signaling theories [22], [23]. Moreover, this study also supports the findings of [4] as they claim that BCT increases transparency and can greatly increase public trust, as supported by organizational information processing theory. Secondly, these study results further widen our understanding of coordination. Also, this work further empirically tested the point raised by [87] that dependence creates coordination, whereas [49]–[51] reported that coordination may be enhanced and reinforced through greater transparency, as supported by TMS theory. The study results show that transparency is an organizational potential, which has a positive and significant effect on humanitarian coordination. Thirdly, as informed by previous literature, trust may be the key element to help coordination, whereas lack of trust impedes coordination [55]. In terms of HL very few researchers have investigated public trust in terms of coordination in the humanitarian setting. These study results empirically proved that public trust is a way to improve coordination in HL, as supported by coordination theory [29]. The overall study findings confirm the study framework based on TMS theory. Lastly, to the best of our understanding, no study has empirically analyzed the integration of IoT devices with BCT in the field of HL. Therefore, the findings will contribute to the stream of the literature by providing updates and support to the previous literature that examined HL performance.

B. PRACTICAL CONTRIBUTION

There is no doubt that the integration of IoT and BCT in HOs is challenging. Thus, HOs search for exclusive strategies and innovations to respond to technology. Nevertheless, the performance and transparency of HOs can be greatly impacted through the distributed ledger technology (DLT). On the other hand, globally, both profit and non-profit organizations are under huge pressure for transparency. In this perspective, this research offers multiple practical implications that might be valuable for management of HOs and policy makers. Firstly, this study significantly enhances HL performance. The integration of IoT devices with BCT will bring positive changes in the HL sector such as available easily information, authentic data, and smart contracts. Blockchain and IoT are new technologies and this study will help researchers, practitioners, students, and scholars to learn and get information about these technologies and to implement them. This study will raise the consciousness of the need to carefully assess decisions relevant to the supply of relief items and to provide practitioners and researchers interested in the theme with directions regarding the key challenges of the incorporation of IoT devices with BCT in HL to be measured.

Second, The primary purpose of this article is to offer a full picture of the need for fast, fair, and safe HL and how this can be achieved. Reference [122] found that BCT and IoT expedite innovation and technical progress in financial security. Indeed, these technologies have established themself in the finance world and have succeeded not only to minimize operational risk but also systemic risk. Furthermore, it makes possible to confirm the financial transactions of the type peer-to-peer and via the DLT to make sure the security and privacy of the transaction between parties (e.g., donors and HOs). In short, these technologies enable disclosure across the way from the transfer funds by donors to the last mile distribution by field workers are the base for fast, fair, and safe HL. Therefore, it can be argued that based on the integration of BCT with IoT, stakeholders can monitor inventory storage and management and can overcome the problems of deviating donation funds and corruption. It can further increase public trust and coordination and ultimately HL performance.

Third, this study shows that BCT has a positive impact on IoT and ultimately, on the performance of HOs. Consequently, HOs can benefit from devoting more consideration to the integration of IoT with BCT. The combination of these two technologies as key drivers for the enhancement of performance will have deep value for the structure and processes of HOs because IoT and BCT can be combined to deliver suitable results to all stakeholders.

Fourth, the study also offers an indirect message for governments and HOs. As the study clearly shows that many HOs do not depend on commercial activities to generate their revenues, they need greater help from donors in order to survive and serve victims. An exciting aspect of this research is for governments to study the role of IoT and BCT in HOs. In other words, responsible authorities can either support HOs in terms of IoT and BCT or can shape effective strategies for better operation of HOs.

Finally, nowadays these technologies (IoT and BCT) are the keys to work in HL and its ranks top on the agenda due to their high effects. Hence, the article reveals the different aspects of IoT and BCT in HL. The planned method will assist as a road-map to HL management to know the variables that need to be managed to enhance performance across HL process.

C. FUTURE RESEARCH DIRECTIONS

The study has some limitations that can be addressed in further research. Nevertheless, this study is the first to shed light empirically on the integration of IoT devices with BCT in HL and can be applied as a reference for future studies. Furthermore, this research was conducted in Pakistan and assessed merely the key dimensions of the integration of IoT with BCT toward HOs' performance. Scholars are encouraged to conduct research in other emerging and developed countries and to explore and compare the implications of IoT and BCT between commercial organizations and HOs. Furthermore, possible moderator(s) as well as mediator(s) can be examined between IoT and BCT and between DLT and transparency to gain more meaningful contributions in this crucial area. The effect of DLT in various humanitarian settings on performance can be examined. Moreover, [4] suggested that collaboration combined with DLT can bring SC resilience. Therefore, we suggest that the mediating role of collaboration can be tested between IoT and HL performance. Although [17] indicated that this is the era of transparent HL processes, except for anecdotal indications, the present literature has remained quiet on the role of transparency, which calls for further research. The results examined integration of IoT with BCT to enhance humanitarian logistics performance and primary data were collected from practitioners belonging to various job functions within HOs. Data were not collected from other stakeholders such as victims, donors, govts, military etc. Henceforth, it can be considered in future studies. The response rate from CEOs was lower than that from other employees, which may have impacted the research findings. Future study is also recommended to conduct in-depth interviews with top-management teams of HOs to identify additional valuable findings in the present study context. Despite these gaps, the study results supported the findings that there is a signification relationship between IoT and BCT and a range of disaster-relevant issues in order to help in disaster-prone areas.

VI. CONCLUSION

The HL is comparatively a new research field. Effective HL is vital because it will protect lives and reduce human suffering. Future study is merely one possible way to accomplish this. Research indicates that the key driver for HOs' performance is effective HL. Currently, there is a wide gap of HL between theoretical research and practice, particularly in emerging countries. Similarly, previous literature on the integration of IoT with BCT and its implications is still in the introduction stage to determine the relationship between these technologies in the HL context. With the development of relevant technology and the advance of academic research, the integration of IoT with BCT may play a key role in the development of the HL in near the future. Furthermore, the area will be crucial for scholars to explore. Hence, this study provides a key contribution to the existing literature through the integration of IoT with BCT. The study clearly recognizes the importance of the application of IoT and Blockchain with the performance of HL, as mediated by transparency. In addition, this study is likely to provide HOs with guidelines to regulate the critical factors to increase the performance of HOs in terms of fast, fair, and safe distribution of relief items. Despite the limitations of the present study findings, they will provide the way for further research to investigate the roles of IoT and Blockchain. Although challenges remain, the future of the integration of IoT with BCT is bright.

APPENDIX

See Table 8.

TABLE 8. Construct operationalization.

S/No	Constructs and Items	References
	Internet of Things (IoT)	
1	My organization utilizes internet of things (IoT) for inter-organization information transfer (IoT1).	[26]
2	My organization utilizes IoT for intra-organization information transfer (IoT2).	
3	My organization utilizes IoT to create and store the information for future use (IoT3).	
4	My organization utilizes IoT for management of relief materials (IoT4).	
5	I agree with the development of my organization's clarity of information to the stakeholders through IoT (IoT5).	[33]
	Block chain Technology (BCT)	
1	We use distributed ledger technology to share information during disaster relief operations (BT1).	[4]
2	We use distributed ledger technology as it helps to maintain confidentiality, integrity, and availability of the data (BT2).	
3	We use distributed ledger technology to improve transparency in disaster relief supply chain (BT3).	
4	We routinely use distributed ledger technology as a data platform that traces the origins, use, and destination of humanitarian supplies (BT4).	
5	We routinely use distributed ledger technology to avoid unreliable information to avoid confusion among partners engaged in disaster relief operations (BT5).	
	Transparency	
1	We routinely share our operational plans (i.e. distribution and storage plans) (TR1).	
2	Our partners routinely gather strategic information related to disaster-affected areas (TR2).	[4]
3	Our partners routinely share strategic information (TR3).	
4	Our local partners share their strategic information related to local culture, government regulations, and other useful information (TR4).	
5	The entire process of the humanitarian logistics in my organization is accurately & transparently disclosed (TR5).	[72]
	Public Trust	
1	Our partners are trustworthy (PT1).	[4]
2	We have no reason to doubt each other's competence and preparation for task (PT2).	
3	While working together on specific tasks, I believe I can rely on them not to cause trouble by careless work (PT3).	
4	My organization has strong confidence that other stakeholders will provide the best advice regarding our businesses for our sake (PT4).	[26]
5	My organization is able to provide sincere aid to our stakeholders (PT5).	
	Coordination	
1	The relief activities of our organization with the new partner are well-coordinated within the humanitarian network we belong to (CO1).	[29]
2	Our organization would try our best to have a positive coordination experience with the new partner (CO2).	
3	The centralized coordination body can coordinate well with the new partner (CO3).	
4	Our organization is open to sharing most information regularly and proactively with the new partner (CO4).	
5	The new partner can approach us at any time for assistance when needed (CO5).	
6	The centralized coordination body can process all information from the network (CO6).	

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