Improving Information Alignment and Coordination in Humanitarian Supply Chain through Blockchain Technology

Abstract

Purpose- The coordination among the various entities such as the military, government agencies, civilians, non-governmental agencies, and other commercial enterprises is one of the most challenging aspects of managing the humanitarian supply chain. Blockchain technology (BCT) can facilitate coordination, but the cost and other hindrances have limited their application in disaster relief operations. Despite some studies, the existing literature does not provide a nuanced understanding of the application of blockchain technology to improve information alignment and coordination. Motivated by some recent examples where blockchain technology has been used to trace and mobilize resources in the form of funds and materials from the origin to the destination, we develop a theoretical model grounded in the contingent resource-based view.

Design/methodology/approach-To empirically validate the model and test the research hypotheses, we gathered cross-sectional data using a structured pre-tested questionnaire. In this study, we gathered our responses from international non-governmental organizations from twenty-four countries. We performed our statistical analyses using variance-based structural equation modeling (PLS-SEM) with the help of commercial software (WarpPLS 7.0).

Findings- The findings of the study offer some useful implications for theory and practice. Our results obtained through statistical analyses suggest that the BCT significantly affects information alignment and coordination. However, contrary to popular beliefs our study suggests that intergroup leadership has no significant moderating effect on the paths joining BCT and information alignment/ coordination. Moreover, we found that the control variable (interdependence) significantly affects the information alignment and coordination further, which opens the room for further investigation.

Practical implication- The result of the study offers some useful guidance. Firstly, it suggests that humanitarian organizations should invest in BCT to improve information alignment and coordination which is one of the most complex tasks in front of humanitarian organizations. Secondly, intergroup leadership may not have desired influence on the effects of BCT on information alignment/ coordination. However, the interdependence of the humanitarian organizations on each other may have a significant influence on the information alignment/ coordination.

Originality/ value- Our study offers some useful implications for theory. For instance, how BCT influences information alignment and coordination was not well understood in the context of humanitarian settings. Hence, this study offers a nuanced understanding of technology-enabled coordination in humanitarian settings.

Key-words: Blockchain Technology, Intergroup Leadership, Humanitarian Supply Chain, PLS-SEM, Information Alignment, Coordination

1. Introduction

The disasters mobilize several organizations, but the coordination among these organizations remains a puzzle that needs to be solved (e.g., Balcik et al. 2010; Akhtar et al. 2012; Moshtari, 2016; Dubey et al. 2019a; Fosso Wamba, 2020; Dubey et al. 2021b; Ruesch et al. 2022). Coordination in the highly networked world presents significant opportunities as well as throw some challenges to deal with. However, despite enormous potential, the study on the technologically driven coordination among relief workers engaged in relief supply chain activities is scant (Ergun et al. 2014; Gupta et al. 2016; Dubey et al. 2019a, 2021b). In a highly chaotic environment, coordination among the humanitarian relief actors holds a significant promise in alleviating humanitarian crises (Ruesch et al. 2022). The alignment between the IT capabilities of the organization and the business strategy provides a cutting edge in highly dynamic, uncertain, and complex environments (Chan and Reich, 2007; Akter and Wamba, 2019; Dubey et al. 2021b). Despite increasing efforts in resolving the misalignment issues concerning organizational capabilities and coordination, the literature on improving alignment between IT capabilities and coordination among humanitarian actors is limited (Stewart et al. 2019; Queiroz and Fosso Wamba, 2021; Stieglitz et al. 2022; Dubey et al. 2022). Moreover, how organizations manage information alignment and coordination among the humanitarian actors through blockchain technology (BCT) is not well understood (Dubey et al. 2020a).

Numerous issues impede coordination which include conflicting goals, opportunistic behavior, misalignment between technology and organization policies, and lack of adequate funding (Modgil et al. 2020; Dubey et al. 2020a, 2021a; Queiroz et al. 2022). Dubey et al. (2021a, p. 62) argue that "*the financial inclusion-access to and use of quality financial services to all income segments of society is one potentially foundational opportunity to bridge the humanitarian-development divide*". Further, the financial support to the low-income population helps them to invest in building assets, and minimize other risks related to health (El-Zoghbi et al. 2017). However, fraud and corruption in the distribution of aid often reduce opportunities for poverty alleviation and reduce inward investment (Ghode et al. 2020).

Hence, therefore, is a greater opportunity to adopt BCT in disaster relief operations to improve the visibility and traceability of funds (Dubey et al. 2020a). BCT is a type of distributed ledger technology (DLT) hosted across multiple users (Hughes et al. 2019; Queiroz et al. 2021). Simply, we can argue that the use of BCT enables safe financial transactions involving multiple partners in the network where no one can make changes or modify details without approval from each member involved in the network (Clohessy and Acton, 2019; Shoaib et al. 2020; Dolgui et al. 2020). Due to the inherent characteristics of the distributed ledger technology, humanitarian scholars find the BCT as a game-changer in managing complex humanitarian relief operations which involve the flow of funds, materials, and information (see, Dubey et al. 2020a; Yong et al. 2020; Yilmaz and Kabak, 2020; Sahebi et al. 2020; Baharmand et al. 2021). Despite the enormous potential of the application of the BCT in tackling humanitarian challenges remains a daunting task in practice (see Figure 1).

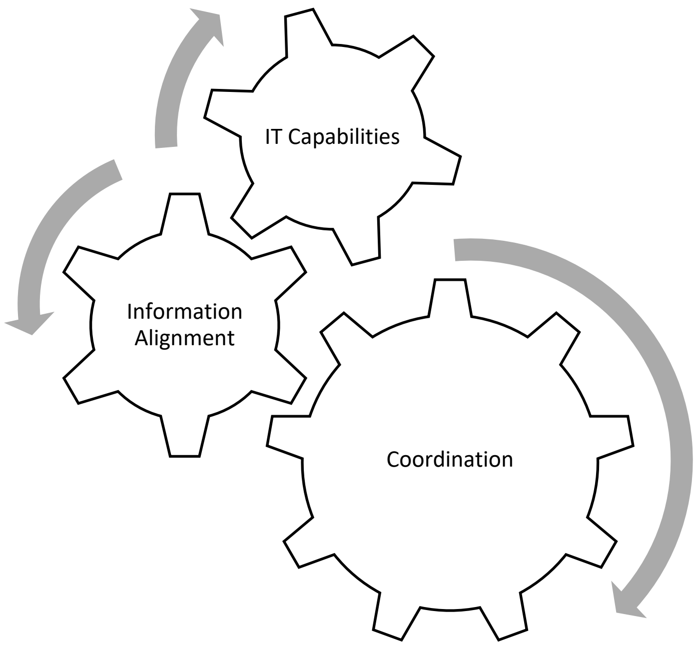

Figure 1: Research Background

We identify this as one of the research gaps that need to be addressed. To address our research gap, we state our first research question (RQ1): *What are the effects of BCT on information alignment and coordination?*

Within humanitarian settings, the role of leadership in tackling crises and providing necessary resources to deal with them has attracted scholarly interest among some academics and policymakers (Dubey, 2022a; Salem et al. 2022). The top managers have an important role to play during humanitarian crises as the nature humanitarian relief actors belongs to a diverse group and work voluntarily with limited training or in some cases have no prior experience (Dubey et al. 2015; Salem et al. 2019). The role of leadership in shaping organizational strategies in dealing with the uncertain environment has been well recognized in the management literature (see, Hambrick and Mason, 1984). The leaders are expected to develop short-term and long-term strategies based on their cognitive abilities and the values derive based on their rich experience that helps the organizations navigate through tough times (Salem et al. 2019). In simple words, the leaders are often considered instrumental in allocating resources and making decisions related to the distribution of relief materials and other forms of assistance to the victims. We acknowledge the role of leadership in tackling complex situations and mobilizing the resources in the resource constraint environment in humanitarian operations management literature that may offer significant insights into the existing debates surrounding the coordination among the humanitarian actors. There exists a rich body of literature focusing on the role of leadership in tackling and resolving conflicts related to the allocation of resources or minimizing opportunistic behavior during uncertain times (Gnyawali et al. 2016).

Disaster relief operations are quite complex in comparison to other commercial activities due to the nature of the operations which involve a team that often works on an ad-hoc basis with a minimum level of training and less familiarity with each other's, we understand that in a such situation different leadership styles are far more suited. Moreover, how leadership facilitates coordination with the help of BCT among the humanitarian actors is a relatively less understood area. Further which leadership styles will be more convenient to tackle humanitarian crises is still not well studied. Following Salem et al. (2019) contribution we understand the "*intergroup leadership theory*" may provide some additional insights that we are currently seeking to explain the coordination mechanism among the humanitarian actors with the help of BCT (Dubey et al. 2021b). To connect missing dots in the literature, we posit our second research question (RQ2): *what are the interacting effects on the paths joining the information alignment/coordination?*

We adopted the scientific process to address our research questions (see Figure 2). To address RQ1 and RQ2, we have grounded our study in the positivism philosophy. The theoretical model is informed by the contingent-resource-based view (C-RBV) (e.g., Aragon-Correa and Sharma, 2003). Following Barney's (1991) seminal contribution, the resource-based view (RBV) has attracted significant attention from management scholars. Despite its immense popularity, the RBV has its limitations which fail to explain under what conditions the resources generate competitive advantage (Brandon-Jones et al. 2014). This phenomenon in the management literature is termed "*context insensitivity*" (Ling-yee, 2007). Hence, following earlier arguments, the scholar notes that CT is the most useful theoretical lens (Sousa and Voss, 2008), that addresses this notion of specific conditions and further offers debate, which helps to understand how various conditions may influence the outcome variable (Eckstein *et al.*, 2015). The essence of CRBV has been well captured in existing studies (Aragon-Correa and Sharma, 2003). We have organized our study into six sections (see Figure 3).

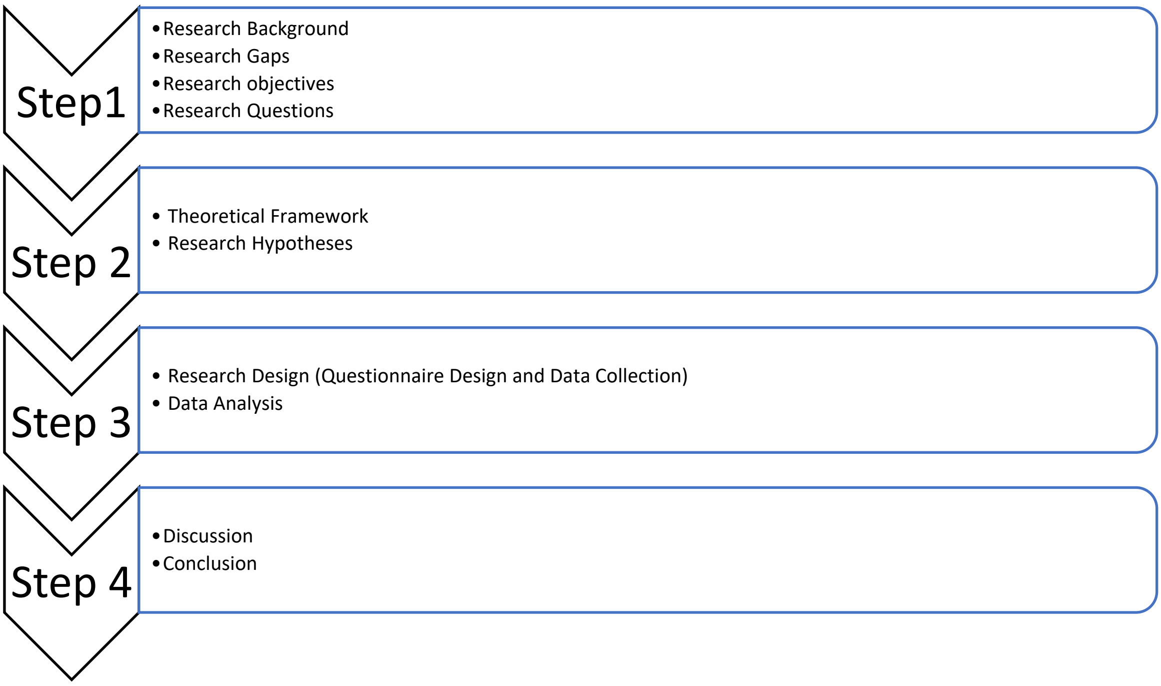

Figure 2: Research Process

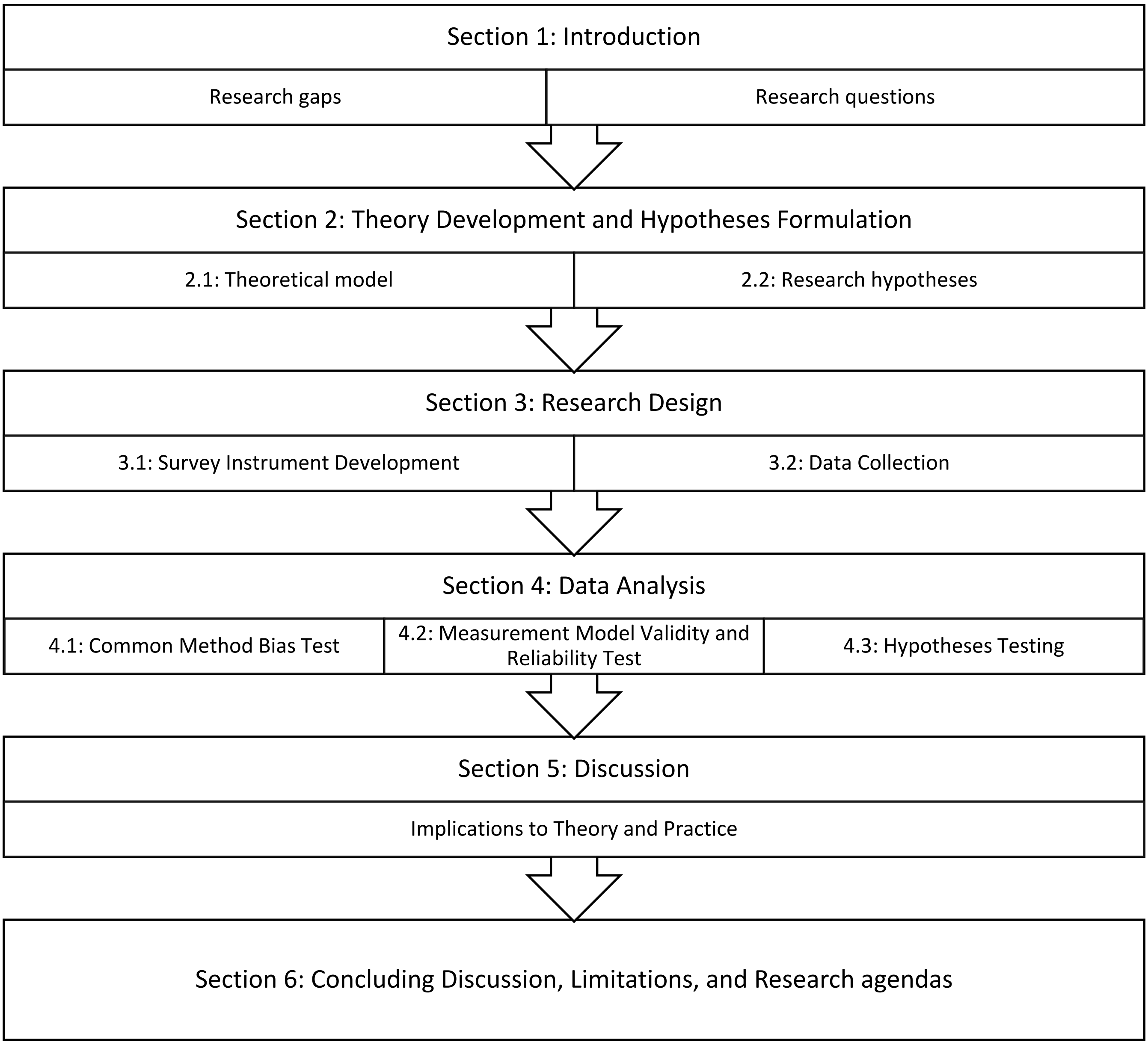

Figure 3: Organization Scheme of the Study

2. Theoretical Development and Hypotheses Formulation

To address our research questions, we propose our theoretical model informed by a contingent resource-based view (C-RBV). In our theoretical model, we conceptualize BCT as a strategic resource that helps improve information alignment and coordination. Further, we consider inter-group leadership as a moderating variable to understand the specific conditions under which BCT effect information alignment and coordination. The CRBV is often termed as a combination of two popular theories: RBV (Barney, 191) and contingency theory (Donaldson, 2001) (see Figure 4).

Despite criticisms, the RBV holds significant promise as a theoretical lens to explain performance (Hitt et al. 2016). The underlying assumptions of RBV limit the utility of the theory in a wider context (Oliver, 1997). Brandon-Jones et al. (2014) further explain how the RBV fails to explain the differential outcomes of the resources and capabilities operating under different conditions. In such a case the scholars have found that the integration of RBV with the CT, provides a better explanation of how the resources and capabilities generate differential outcomes under the moderating influence of specific contingency factors (see, Sousa and Voss, 2008; Brandon-Jones et al. 2014; Eckstein et al. 2015). The contingency factors include a wide range of factors such as culture, complexity, leadership, organization size, type of ownership, absorptive capacity, or any conditions that may not have a direct influence on the outcome variables but help enhance the direct effect of the predictors on the outcome variables (Sousa and Voss, 2008). The factor of top management commitment has been identified as a key contingent factor. In response to criticisms related to the RBV and its application, some scholars have suggested a way out by integrating two perspectives that may take care of the static nature of the RBV. For instance, Aragon-Correa and Sharma (2003) suggested combining CT with the RBV to address one of the main limitations of the RBV (i.e., context insensitivity), which has been further empirically examined by various scholars in different contexts (see, Brandon-Jones et al. 2014; Eckstein et al. 2015; Dubey et al. 2020b).

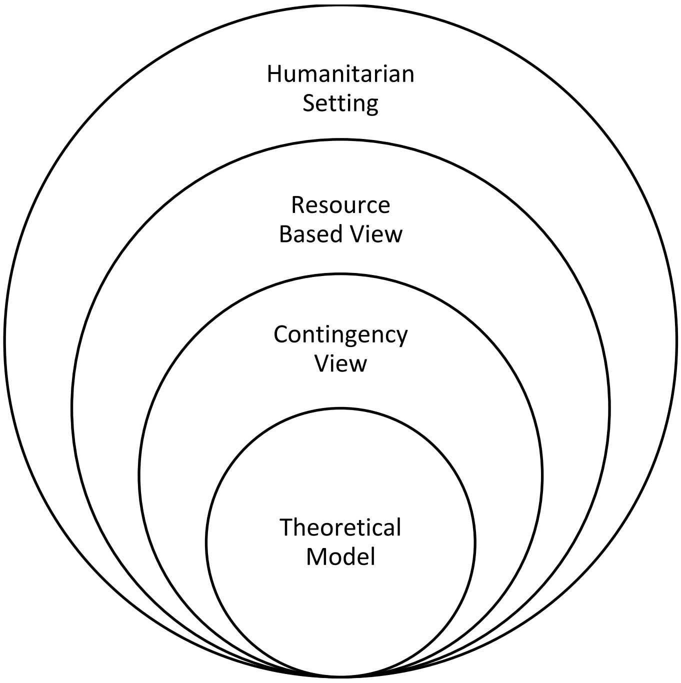

Figure 4: Underpinning Theory

2.1 Theoretical Model

The cornerstones of our theoretical model are RBV and CT (see Figure 5). The contingency resource-based view (C-RBV) has gained significant attention from the operations and supply chain management community to examine how resources and capabilities generate competitive advantage in highly uncertain environments (see, Brandon-Jones et al. 2014; Eckstein et al. 2015; Dubey et al. 2020b). RBV is often considered a suitable theoretical lens to understand value realized through the combination of resources and capabilities. Informed by the logic of RBV, in this study we consider the role of BCT in improving the information alignment and coordination among the disaster relief workers in humanitarian supply chains. The information alignment refers to the dynamic interactions and continuous adjustment at all levels between the humanitarian organizations engaged in the humanitarian operations to build trust and commitment and further enhance the coordination (Caldwell et al. 2008; Dubey et al. 2021b). There exist a rich body of empirical literature which indicates that the resources and capabilities generate a differential outcome (Mandal et al. 2009). The changes in the resource constraints and the top management decision may have a significant influence on the performance. This view is grounded in the contingency theory (CT). Thus, based on these two theories: RBV and contingency theory (intergroup leadership), we develop our theoretical model, which explains the effective and efficient use of emerging technologies like BCT to improve information alignment and coordination in the humanitarian supply chain under the moderating effect of intergroup leadership.

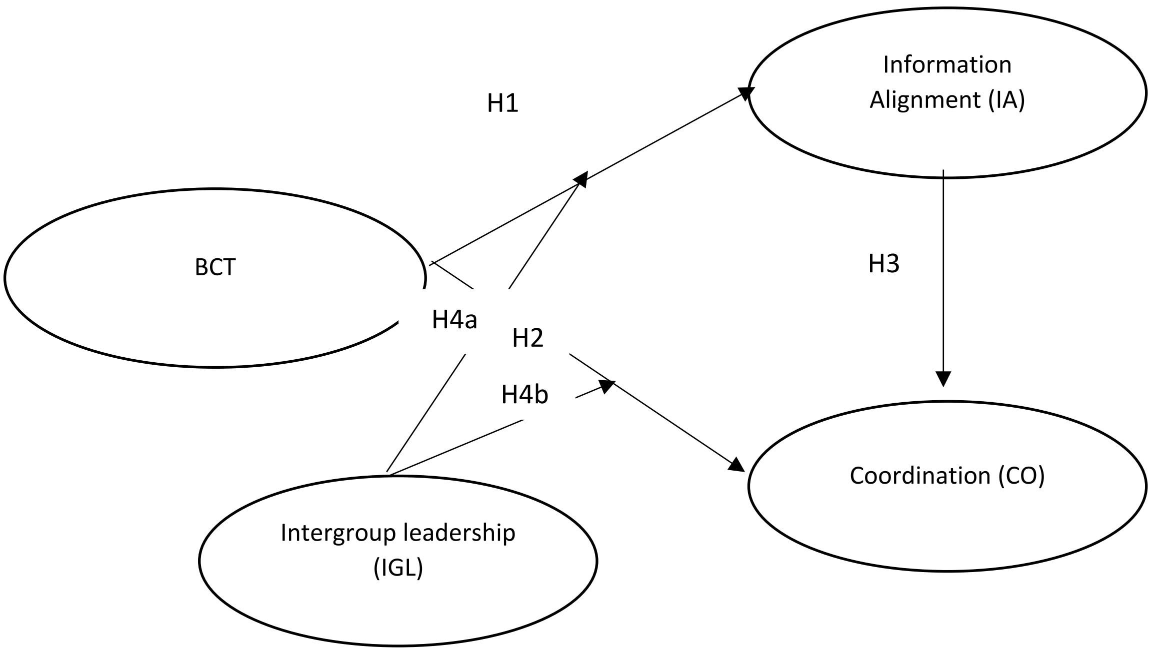

Figure 5: Theoretical Model

2.2 Research Hypotheses

2.2.1 Impact of Artificial BCT on Information Alignment/Coordination

Sharing a common vision, managing common expectations, facilitating coordination, and information sharing are considered cornerstones of humanitarian operations (Altay and Labonte, 2014). Tatham and Rietjens (2016) argue that understanding roles, relationships, capacities, motivations, and proper exchange of information in complex environments is essential for effective coordination. In complex environments like humanitarian operations, information sharing among disaster relief workers is often considered critical for better coordination (Altay and Pal, 2014; Altay and Labonte, 2014). The most common barrier to coordination is poor information alignment among the participating humanitarian organizations. Information alignment is defined as "*the degree to which the information technology mission, objectives, and plans support and are supported by the business mission, objectives, and plans*" (Reich and Benbasat, 2000, p. 82).

McIsaac et al. (2019) argue that the distributed ledger technology-based BCT offers a unique capability to ensure that the relief package reaches the right victims affected during disasters. BCT offers unique opportunities to improve the security and traceability of the information, funds, and materials flow in the humanitarian aid supply chain (Dubey et al. 2020a; Ozdemir et al. 2021). Thus, we can argue that BCT and information alignment are complementary, in the sense that each demand and supports the other (Gligor et al. 2022). Hence, we expect organizations involved in humanitarian activities, such as disaster relief, to understand the connections between BCT, information alignment, and coordination. We hypothesize these connections as:

H1: BCT has a positive effect on information alignment.

H2: BCT has a positive effect on coordination.

H3: IA has a positive effect on coordination

2.2 The Moderating Role of Intergroup Leadership

The organization strategy reflects the top manager's beliefs and commitment (Hambrick and Mason, 1984; Dubey et al. 2021b). Therefore, leaders' positive beliefs about the usefulness of BCTs translate into certain managerial actions that help organizations assimilate BCTs as an integral part of their organizational design (Taufaili et al. 2021). To drive technology-driven coordination among the humanitarian organization, the role of leadership is highly critical, especially during the adoption of BCT and creating awareness among the humanitarian relief workers. The leaders publicly championing the new emerging technologies or systems lends legitimacy to the adoption of the BCT and the changes imposed by the managers in the work routines (Sarker et al. 2021). The disaster relief operations involve humanitarian actors from diverse groups. Each group has its own identity such as ethnicity, culture, language, and own set of beliefs that often act as barriers to establishing coordination. Hence, to iron out the visible differences that exist between various sub-groups, the role of leadership is considered pivotal (Hogg, 2015; Salem et al. 2019; Dubey et al. 2021b). Hence, where there is a high degree of diversity between these organizations, intergroup leadership is often seen as beneficial because it does not cause an identity crisis between these organizations (Salem et al. 2019; Dubey et al. 2021b). On the contrary, it respects the identity of each organization and views diversity as an important feature of effective disaster relief management. Following intergroup leadership theory (see Hogg et al., 2012), we argue that leaders develop unique and useful traits through group meetings, face-to-face conversations, or after-work activities that create bonds. between different groups involved in relief operations during natural disasters. These traits often help leaders resolve conflicts arising from a lack of visibility or transparency. Thus, we view cross-group leadership as an addition to BCT's capabilities in the sense that having effective leadership makes BCT more valuable and efficient in coordinating and coordinating information. Therefore, we assume the following:

H4: Intergroup leadership positively moderates the relationship between BCT and: (a) information alignment and (b) coordination;

3. Research Design

To test our research hypotheses, we relied on perceptual data gathered using a survey-based instrument. The cross-sectional data were gathered following Stern et al. (2014) total design test method from 24 international non-governmental organizations spread across the globe [*this is an extension of the previous study by Dubey et al. (2020, 2021b)*] (see Appendix A). The survey-based instrument is a cost-effective as well as the most suitable way to measure the behavioral constructs (Boyer and Swink, 2008). Despite several advantages, the survey-based method has its limitations. One such limitation may affect the results of the study (i.e., common method bias). The common method bias is an inherent problem that cannot be eliminated. However, we can reduce the negative effects of the common method bias on results through procedural remedies that include questionnaire design (Ketokivi and Schroeder, 2004; MacKenzie and Podsakoff, 2012). Hence for our study, we designed a multi-informant questionnaire. We particularly reached out through email to the senior managers who have good exposure to the use of technology in the decision-making process in humanitarian relief operations. We conducted our study with the assistance of the United Nations Office for the Coordination of Humanitarian Affairs (OCHA). The OCHA has provided us with details of the international NGOs.

3.1 Survey Instrument Development

We designed our questionnaire following two steps process (see, Dillman and Bowker, 2001). To begin with, we undertook an extensive review of literature drawn from operations management, strategic management, relationship marketing, information management, and organizational behavior. Next, we tried to adapt the constructs borrowed from other disciplines in the context of humanitarian settings (see, Dubey et al. 2020a, 2021b). We have used a seven-point Likert scale with anchors varying from strongly disagree (1) and strongly agree (7). The use of the seven-point Likert scale was to ensure statistical variability among the perceptions gathered from the respondents (see Appendix B).

We next pre-tested the questionnaire to ensure that the respondents do not face any difficulties while filling up the questionnaire in two stages: expert opinion and pilot study (Boyer and Pagell, 2000). Firstly, we sent our questionnaire to five academicians from the humanitarian supply chain management field to read the questionnaire and provide their input related to the clarity, relevance, and ambiguity of the measuring items (DeVellis, 1991; MacKenzie and Podsakoff, 2012; Dubey et al. 2021b). Based on the input from the academicians, we have reworded the sentences. In the next stage, we sent our questionnaire through email to 37 managers having rich experience in managing humanitarian relief operations. We requested the managers to fill up the questionnaire so that they can share their views related to the clarity and completeness of the questions in the questionnaire. We incorporated the suggestions received from these managers before sending out the questionnaire for the data collection.

3.2 Data Collection

This study is an attempt to extend our previous studies to understand "*when*" and "*how*" the BCT help improve the information alignment and coordination among the participating humanitarian organizations (see, Dubey et al., 2020, 2021a). The study was conducted between 15 April 2021-23 November 2021. For the study, the authors have hired some professionals having decent exposure to working on projects. In this case, we have sought their assistance in sending emails and following up with the respondents at regular intervals through reminders in a polite way. The content of the email was developed by the lead author to avoid any sort of confusion. Nearly 1400 emails along with the attachment were sent to the respondents (455 organizations). In the cover letter attached to the questionnaire, we assured the respondents that the study is conducted for academic purposes. Hence the entire details of the respondents will be treated confidentially. After three reminders we received good responses. We carefully checked all the responses and finally, we arrived at 431 usable responses from 143 organizations (see Appendix A), with an effective response rate of 31.43 %, with at least three participants from each organization.

Although we collected data at a point in the time (i.e., cross-sectional data), still we cannot deny that the responses we gathered only represent 31.43% of the target respondents. In such a case we compared the responses of the early respondents with late respondents following Armstrong and Overton (1977). We performed the Student's t-test and the results suggest no significant difference (p=0.53). Fawcett et al. (2014, p. 11) argue that "*comparing early to late respondents is not a particularly strong test of nonresponse bias. You create more confidence in your data if you track your respondents and then compare them to nonrespondents*". However, following the recommendations of Fawcett et al. (2014), the lead author contacted some of the non-respondents through MS-Team/Zoom and collected their responses. Wagner and Kemmerling (2010) have expressed their reservations regarding direct comparisons between respondents and non-respondents, which comes with its limitations in terms of loss of anonymity. Hence, we cautiously evaluated the response that we gathered through direct conversation and the previous responses. Thus, we conclude that the non-response bias is not a major issue in our study.

4. Data Analysis and Results

We performed our statistical analyses on our cross-sectional data using the PLS-SEM technique to test our theoretical model. In this study, we have used Warp PLS 7.0 to address criticisms of traditional PLS-SEM methods due to them being composite-based, not factor-based (Kock, 2019).

4.1 Multiple Rater Agreement Measures

We have gathered multiple responses from each organization to minimize the common method bias resulting from the response of a single respondent (see Figure 6). However, agreement among the responses needs to be within the acceptable range (see Appendix C). Based on our results we conclude that there is a significant inter-agreement among the responses that we gathered for testing our research hypotheses.

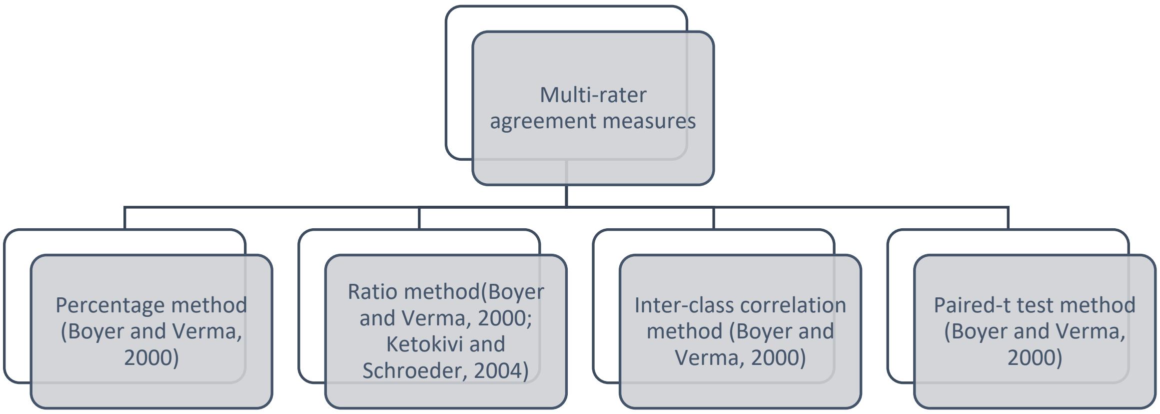

Figure 6: Inter-agreement Test

4.2 Common Method Bias (CMB)

MacKenzie and Podsakoff (2012, p. 542) argue that "*there is a great deal of evidence that method bias influences item validities, item reliabilities, and the covariation between latent constructs*". Some scholars have noted that the common method bias (CMB) and the low internal consistency may not have a significant influence on the conclusions of the study (Doty and Glick, 1998). However, it is now well established within operations and supply chain management studies that rigorous evaluation of the psychometric properties of the latent constructs is essential (Ketokivi and Schroeder, 2004). Due to its low cost and relatively easier to gather data, the survey-based method has gained significant footing as one of the most popular methods (Flynn et al. 1990; Boyer and Swink, 2008). However, despite several benefits of the survey-based method, the common method bias is one of the main drawbacks that limit the value of the results obtained using statistical analyses (Podsakoff et al. 2003; Ketokivi and Schroeder, 2004; MacKenzie and Podsakoff, 2012). In our study, we adopted two ways to assess the CMB. Firstly, we carried out a conventional one-factor Harman's test (a single factor explained nearly 21.21% of the total variance). However, scholars have cautioned about the reliability of the result obtained through the one-factor Harman's test (Podsakoff et al. 2003; Hulland et al. 2018). Secondly, we examined the CMB using the correlation marker method (Lindell and Whitney, 2001). We adopted an independent variable for the CMB-induced partial correlation. Additionally, we determined significant correlations as proposed by Lindell and Whitney (2001). We observed minimal differences between the adjusted and unadjusted correlations. Hence, based on procedural remedies that we have adopted before data collection and further the results derived using suggested methods, we can argue that to an extent we have managed to reduce the negative impacts of the CMB on our results.

We also reported the nonlinear bivariate causality direction ratio (NLBCDR) as one of the indicators to determine endogeneity (Kock, 2017). Kock (2012, p. 52-53) defines NLBCDR as "*measures the extent to which bivariate nonlinear coefficients of association provide support for the hypothesized directions of the causal links in the proposed theoretical model*". The threshold value of NLBCDR should be greater than or equal to 0.7. In our case, we observed, NLBCDR=0.99 (approx.), which is greater than the critical value of 0.7. Hence, we argue that endogeneity is not a major concern. We have further provided the values for model fit and quality indices supporting this conclusion in Appendix D.

4.3 Measurement Model Reliability and Validity

To validate the theoretical model, we relied on existing literature (see, Fornell and Larcker, 1981; Peng and Lai, 2012, we checked the following assumptions (see Figure 7). We have outlined the factor loadings (λi), scale composite reliability (SCR), and average variance extracted (AVE) of the constructs in Figure 5 in Table 1. The values in Table 1 exceed the cut-off values as suggested in the literature (see, Fornell and Larcker, 1981), we can argue that our constructs in Figure 5, satisfy the convergent validity criteria.

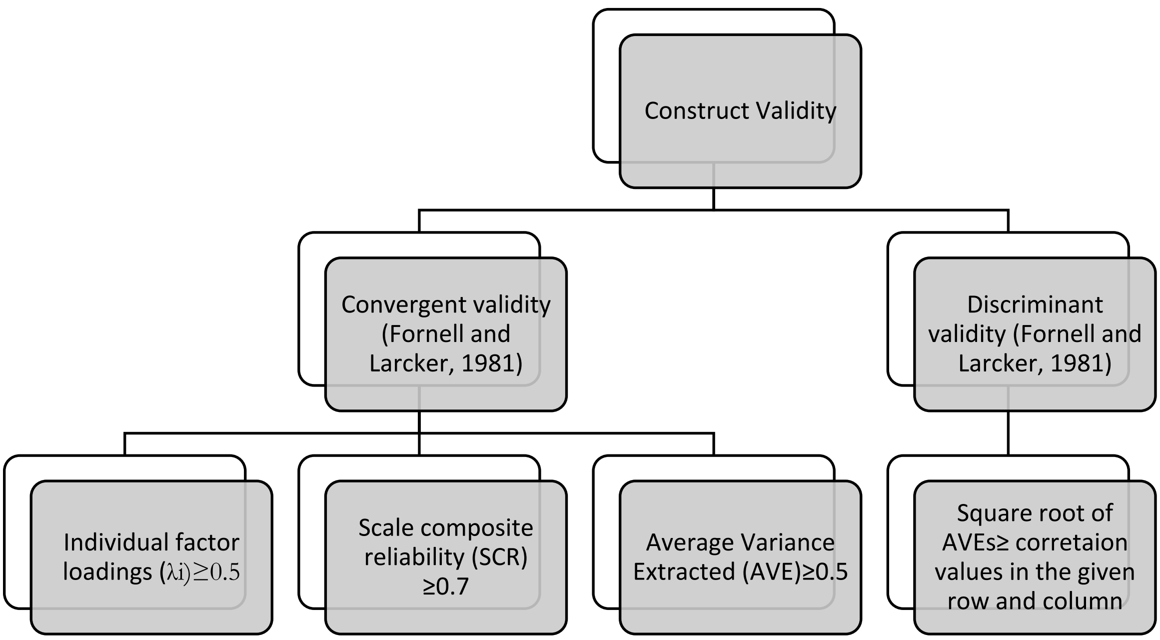

Figure 7: Criteria for Checking Construct Validity

Table 1: Measurement Properties of Constructs (Convergent Validity) (N=143)

	Factor Loadings	Variance	Error	SCR	AVE
BCT1	0.89	0.79	0.21	0.93	0.77
BCT2	0.95	0.91	0.09		
BCT3	0.94	0.89	0.11		
BCT4	0.70	0.50	0.50		
IA1	0.75	0.56	0.44	0.95	0.81
IA2	0.92	0.84	0.16		
IA3	0.94	0.89	0.11		
IA4	0.99	0.97	0.03		
CO1	0.96	0.91	0.09	0.94	0.80
CO2	0.98	0.96	0.04		
CO3	0.94	0.89	0.11		
CO4	0.66	0.43	0.57		
IGL1	0.98	0.97	0.03	0.94	0.80
IGL2	0.96	0.92	0.08		
IGL3	0.93	0.86	0.14		
IGL4	0.68	0.46	0.54		
I1	0.98	0.97	0.03	0.97	0.94
I2	0.96	0.92	0.08		

Notes: *BCT, Blockchain Technology; IA, Information Alignment; CO, Coordination; IGL, Intergroup Leadership; I, Interdependency.*

Secondly, we analyzed the divergent validity of the constructs (see Figure 5). We analyzed the rotated factor loadings matrix, which indicates that no items are cross-loaded on any other construct (Appendix E) (Dubey et al. al., 2019). Next, we checked the leading diagonal of the matrix (see Table 20). We observed that the leading diagonal elements (square root of the AVE) are greater than the correlation values in the given row and column of the diagonal. This conforms the Fornell and Larcker (1981) findings

Table 2: Construct Correlations (Divergent Validity) (N=143)

	BCT	IA	CO	IGL	I
BCT	***0.88***				
IA	0.80	***0.90***			
CO	0.74	0.86	***0.89***		
IGL	-0.09	-0.08	-0.05	***0.89***	
I	0.71	0.81	0.86	-0.21	***0.97***

Notes: *BCT, Blockchain Technology; IA, Information Alignment; CO, Coordination; IGL, Intergroup Leadership; I, Interdependency.*

4.4 Hypotheses Testing

We tested our research hypotheses using WarpPLS 7.0. Our results suggest that the use of blockchain technology (BCT) in humanitarian relief activities has a positive and significant influence on information alignment (IA) (β=0.46, $p<0.01$). Whereas the IA has a significant positive effect on the coordination (CO) (β= 0.44, $p<0.01$). However, the BCT has no direct significant effect on the CO (β=0.06, p=0.17). This suggests that the BCT has a significant influence on enhancing coordination among the humanitarian supply chain actors engaged in the relief activities, under the mediating influence of the IA.

However, we found intergroup leadership (IGL) has no significant moderating influence on the paths joining BCT and IA/CO (see Table 3). The previous studies show that there exists tension among various groups engaged in humanitarian relief operations which may be attributed to significant differences in their organizational culture, their guiding philosophy or different languages spoken, or sometimes their different religious faith. Hence, the traditional leadership theory focuses on a single group, hence not capable to manage conflicts resulting in complex humanitarian relief operations where several groups are engaged with little or no formal training. The IGL has no significant role to play in the context of the technology-based coordination among the humanitarian actors. Hence, we can conclude based on our statistical results that the IGL may be considered an independent variable. However, we found that the control variable (interdependence) among the humanitarian actors is significantly related to the IA and CO which further opens new frontiers that need to deal with in future research.

Table 3: Structural Estimates (N=143)

Hypothesis	*Effect of*	*Effect on*	*β*	*p-value*	*Results*
H1	BCT	IA	0.46	<0.01	supported
H2	BCT	CO	0.06	0.17	Not-supported
H3	IA	CO	0.44	<0.01	supported
H4a	BCT*IGL	IA	0.01	0.45	Not-supported
H4b	BCT*IGL	CO	0.06	0.17	Not-supported
	Control variables				
	I	CO	0.43	<0.01	supported
	I	IA	0.47	<0.01	supported

Notes: *BCT, Blockchain Technology; IA, Information Alignment; CO, Coordination; IGL, Intergroup Leadership; I, Interdependency.*

To further examine the explanatory power of our theoretical model (see Figure 5) we analyzed the explanatory power (R^2) of the endogenous constructs as shown in Figure 8. The R^2 of IA is 0.76 (approx.) and CO is 0.82 (approx.).

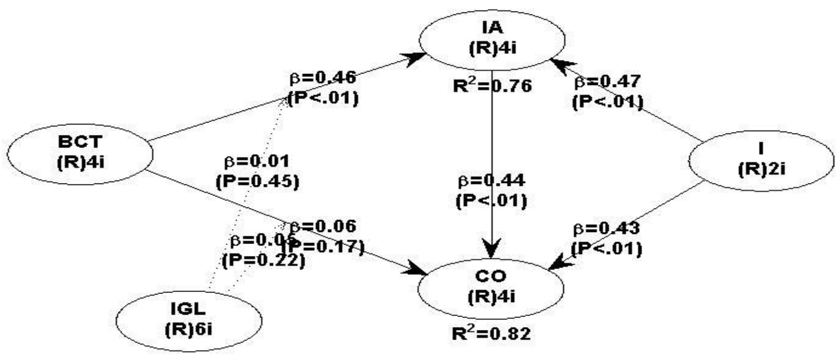

Figure 8: Final Model

5. Discussion on Implications for Theory and Practice

Our study results provide a nuanced understanding of the relationship between BCT and the alignment of information as resources, from a resource-based approach and coordination, from a relational value perspective. They explain how benefits flow from the collaborative relationships developed through the BCT and the alignment of information through partnerships among partners engaged in disaster relief efforts.

The results, derived from analyses, highlight how the interaction between strategic resources contributes more to improving coordination between partners in disaster relief operations of disaster. The interaction of these resources and relational value (i.e., coordination), under the moderating effect of intergroup leadership, further improves informational alignment and coordination. Collectively, these results shape the theory and offer valuable guidance for managers engaged in disaster relief operations. Additionally, the findings raise potential research questions that help advance future research.

The results of the study offer some interesting insights which might be useful to understand how the combination of the resource-based view and contingency theory can help understand the complex interactions between technology and human behavior during uncertain times such as disasters. Although theorists have divergent views related to the usefulness of the resource-based view and particularly in the context of the humanitarian supply chain the potential usefulness of the theory is limited. Following Hitt et al. (2016) arguments, the potential usefulness of the RBV can be better realized through minor adjustments depending on the situation. The previous studies (see, Dubey et al. 2020a; Dubey et al. 2021 b) have examined the associations between (BCT & CO) and (AI-BDAC & IA). However, the effect of the BCT on information alignment and coordination was not well established in humanitarian settings. Moreover, the theories that we use in our study have been used to examine the performance of an organization (Gunasekaran et al. 2018) but the application of these theories to understand complex humanitarian operations has received significantly less attention (see, Salem et al. 2019; Prakash et al. 2020; Dubey et al. 2021b). Hence, our findings contribute to the RBV as advancing the RBV in a humanitarian context is hampered by the incompatibility of some key assumptions of the humanitarian aid supply chain. In this study, we proposed the contingent RBV (CRBV), which builds upon the RBV and contingency theory, and is a better alternative to examine complex situations in humanitarian settings. Secondly, our study further answers the Ergun et al. (2014) research calls for more data-driven research to understand the complex interaction between technology and coordination/collaboration in humanitarian settings. Our results demonstrate that the BCT under the mediating effect of information alignment has a significant effect on enhancing coordination among humanitarian organizations. Previous studies have tried to examine the direct effects of enabling technologies on coordination or collaboration. However, our study further suggests that in most cases the benefits from the adoption of the technologies are quite limited and this may be attributed to poor information alignment.

Besides useful implications for theory, the study also provides rich guidance to the managers engaged in humanitarian relief operations. The coordination among humanitarian organizations remains a challenging task. To facilitate effective coordination the United Nations has developed clusters to facilitate information sharing and resources among the participating humanitarian organizations. Our study results provide clarity to the humanitarian organizations that with the help of blockchain technology how humanitarian organizations can improve information alignment and coordination which has been one of the major concerns in recent times (see Ruesch et al. 2022).

Finally, our study also observes that interdependence has a significant influence on information alignment and coordination among humanitarian organizations. We understand that coordination in the humanitarian supply chain is a complex interaction of various actors each with different aims, goals, capacities, and logistics expertise. Our study confirms previous studies that interdependency has a positive impact on the level of coordination (Rusbult and Van Lange, 2008; Moshtari, 2016). Hence, the essence of the group interaction is not determined by the similarity or differences of the actors involved in the disaster relief action. It is the level of interdependence on each other's defines the level of trust, cooperation, and coordination. Hence humanitarian organizations need to work on the interdependence dimensions for better information alignment and effective coordination.

6. Concluding Discussion, Limitations, and Future Research Agenda

Humanitarian organizations are increasingly realizing the potential of technology-enabled coordination (Ergun et al. 2014). The donors are increasingly demanding far more accountability and visibility about their donations and how their donations are utilized in disaster relief operations (Salem et al. 2019; Dubey et al. 2021b). Our study contributes to providing a nuanced understanding of technology-enabled coordination in humanitarian settings. However, despite our efforts to use established organizational theories and test the research hypotheses using multi-informant data gathered from international NGOs engaged in disaster relief efforts with the assistance of world reputable agencies, we still find several lacking in our study which we believe need to be taken care of during future studies.

6.1 Limitations

Firstly, we have focused on the application of a few antecedents, like BCT and information alignment, to empirically investigate the interplay of these two resources and capabilities in enhancing coordination among the humanitarian organizations involved in disaster relief operations. Hence future studies can explore how other organizational factors may enhance coordination in the technology era, including how factors might interact in negative ways, such as the misuse of technology providing an inhibitor to coordination. Additionally, our current study has not considered other potentially significant variables, such as organizational culture or the attitude of those involved in humanitarian activities toward the usage of technologies.

Secondly, disparities of power amongst partners may yield different outcomes. Although we have partially recognized the potential influence of disparity in power structures and their effects on coordination by introducing the concept of intergroup leadership to iron out such differences, still our understanding of the interplay of intergroup leadership in complex humanitarian contexts remains limited. Although Salem et al. (2019) offer a comprehensive perspective, still a lot of questions relating to intergroup leadership in the context of humanitarian settings need answering.

Thirdly, we tested our research hypotheses using survey-based data. The cross-sectional data has several drawbacks which we have discussed in the data analysis section (see, Boyer and Swink, 2008). Following, Flynn et al. (1990) contribution the operations and supply chain management have increasingly relied upon survey-based data to test their research hypotheses. The survey-based data is relatively easier to collect, and sometimes perceptual data may be more reliable than secondary data. Despite some merits, we cannot deny that the survey-based data has its own limitations which only can be taken care of using a mixed methods approach.

6.2 Future Research Agenda

Our results suggest that the BCT has a significant influence on the information alignment and coordination among the humanitarian actors involved in disaster relief operations. This study further supports the long-standing research call of the previous scholars (see, Lumineau et al. 2021). To further address some unanswered research questions, we propose a research agenda for organizational and operations management scholars to advance the theoretical understanding of how blockchain technology can improve the way human actors coordinate. Following, Lumineau et al. (2021) and Whetten (1989), we organize our research agendas into six questions (what, why, how, who, when & where) (see Figure 9). We hope these research agendas provide food for thought.

To address ***"What"***, the organizational and humanitarian scholars can explore enablers and barriers to the adoption of the BCT in the humanitarian supply chain context. To answer the ***"Why"*** of the blockchain mechanism, the organizational theoretic lens could provide a useful way to address questions related to the motivation behind the adoption of the BCT or to explain the usefulness of the BCT especially when the humanitarian actors are operating under resource constraint environment. In addition, theories in the reference disciplines, such as resource orchestration theory, awareness-motivation-capability (AMC) framework, stakeholder theory, social exchange theory, contingency theory, resource dependence theory, and institutional theory, can help analyze, explain, predict, and action the BCT in the humanitarian context. Similarly, the mixed method can answer ***"how"*** (see, Boyer and Swink, 2008). About the role of ***"Who"***, crisis leadership theory and responsible management theory can help to sense, seize, and reconfigure BCT capabilities in extremely unpredictable situations like disasters. Last, we recognize how the context plays a significant role in the effectiveness of the BCT. Hence by answering ***"when"*** and ***"where"***, the scholars may address long-standing research calls related to the situations under which the BCT offers better results to tackle complex humanitarian relief actions which involve diverse actors. By answering six key questions (see Figure 9), future studies can offer a nuanced understanding of a BCT in the humanitarian context, understand the boundary conditions and nomological relationships for a substantive theory and create new horizons for future BCT studies.

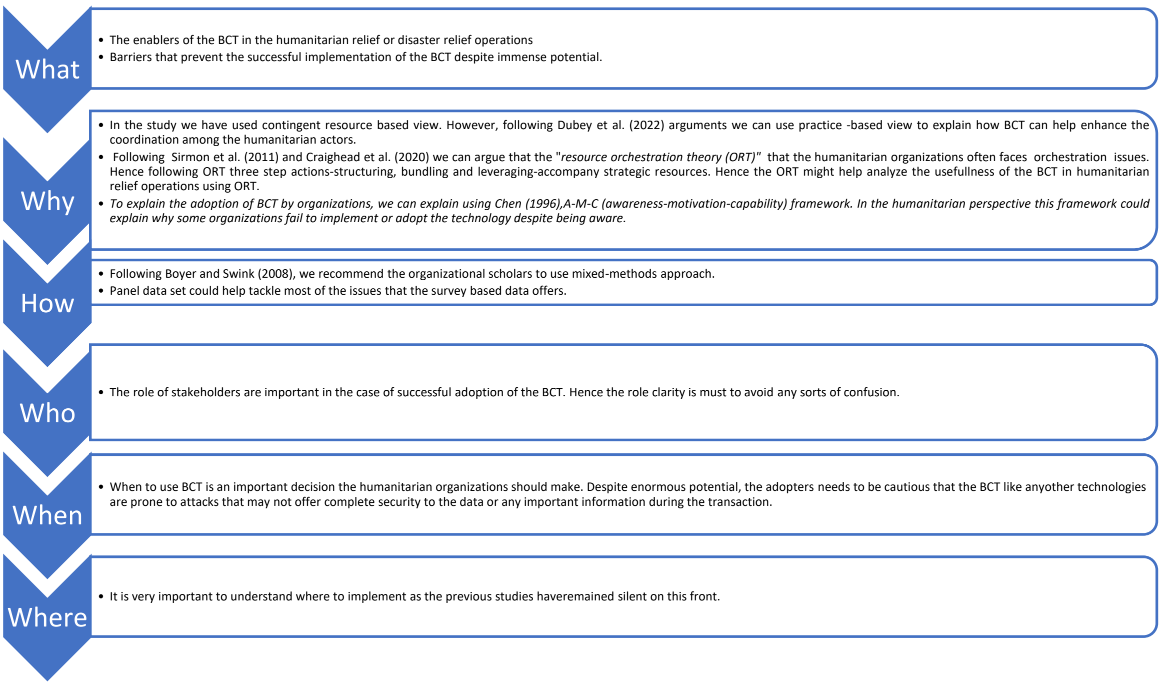

Figure 9: Future Research Agendas

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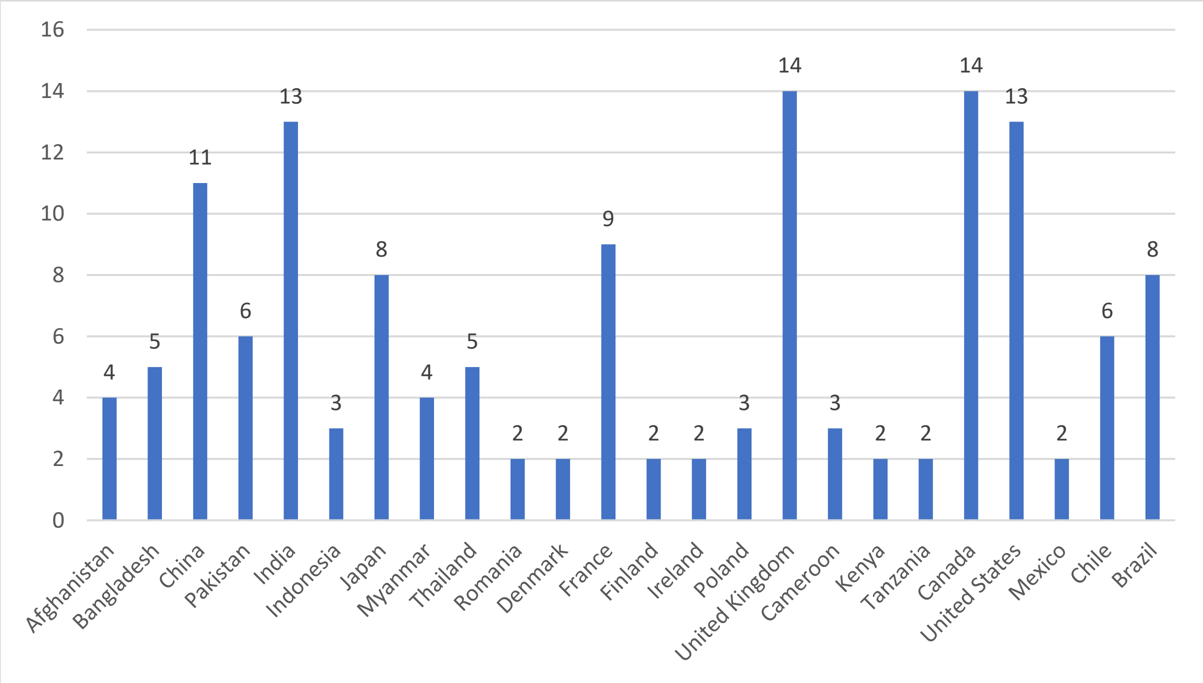
Appendix A: Demographic Profile of the responding organizations (N=143)



Appendix B: Operationalisation of Constructs

Construct and Derivation	**Types**	**Measures**
Blockchain technology adoption (BCT) (Adapted and modified from Dubey et al. 2020a)	Reflective	We use blockchain technology to avoid the distortion of information flow (BCT1) We use blockchain technology to trace the flow of funds (BCT2) We use blockchain technology to trace the flow of relief materials (BCT3) We use blockchain technology to improve the coordination among the partners (BCT4)

Information Alignment (IA) (Dubey et al. 2021b)	Reflective	We agree on sharing of information related to our actions during crises (IA 1) We regularly interact with our service providers related to our strategic needs (IA2) We regularly communicate with the participating humanitarian organizations related to future requirements of relief materials (IA3) We create compatible information systems among various humanitarian organizations (IA4)
Coordination (CO) (Dubey et al. 2019b)	Reflective	We regularly share the information with our partners to avoid any duplication of efforts (CO1) We agree that the coordination is mutually beneficial for all of us (CO2) We jointly plan our activities (CO3) The participating humanitarian organizations are satisfied with the coordination (CO4)
Intergroup Leadership (IGL) (Hogg et al. 2012; Salem et al. 2019)	Reflective	The field manager interacts with the humanitarian relief workers regularly to understand the situations (IGL1) The field managers always try to resolve the differences between the humanitarian actors due to cultural differences (IGL2) The field manager aids the use of the technology efficiently (IGL3) The field manager encourages the use of technology to improve the coordination among the diverse actors engaged in the disaster relief action (IGL4)
Interdependency (I) (Brown et al. 1995)	Reflective	It would be costly for our organization to lose its coordination with the partner (I1) This partner would find it costly to lose the coordination with our organization (I2)

Notes: *BCT, Blockchain Technology; IA, Information Alignment; CO, Coordination; IGL, Intergroup Leadership; I, Interdependency.*

Appendix C: Measures of inter-rater agreement

Constructs	Percentage method (%)	Ratio method	Inter-class correlation coefficient	Paired t-test
BCT	85	0.89	0.31	Not-significant
IA	82	0.86	0.36	Not-significant
CO	81	0.85	0.33	Not-significant

IGL	86	0.90	0.31	Not-significant
I	88	0.92	0.28	Not-significant

Notes: *BCT, Blockchain Technology; IA, Information Alignment; CO, Coordination; IGL, Intergroup Leadership; I, Interdependency.*

Appendix D: Model fit and quality indices (N=143)

Model fit and quality indices	Value from analysis	Acceptable if	Reference
APC	0.276, p=0.001	p<0.05	Rosenthal and Rosnow (1991)
ARS	0.791, p<0.001	p<0.05	
AVIF	2.455, p<0.001	p<0.05	Kock (2012)
Tenenhaus GoF	0.760	Large if ≥0.36	Tenenhaus et al. (2005)

Appendix E: Parsimonious Structure

	BCT	IA	CO	IGL	I
BCT1	0.89				
BCT2	0.95				
BCT3	0.94				
BCT4	0.70				
IA1		0.75			
IA2		0.92			
IA3		0.94			
IA4		0.99			
CO1			0.96		
CO2			0.98		
CO3			0.94		
CO4			-0.66		
IGL1				0.98	
IGL2				0.96	
IGL3				0.93	
IGL4				0.68	
I1					0.98
I2					0.96