Unleashing the potential of Digital Technologies in Emergency Supply Chain: The moderating effect of Crisis Leadership

Abstract

Purpose-The stakeholders are now demanding more visibility and role clarity in the humanitarian supply chain to improve collaborative efforts. Using a contingent resource-based view, the author studies crisis leadership as a complementary organizational resource for the successful adoption of digital technologies in the emergency supply chain. The author further examined the relationships between digital technologies on information visibility and collaboration under the moderating effects of intergroup leadership.

Design/methodology/approach- The author gathered data from 117 NGOs in India using a multi-informant questionnaire. The author further tested the research hypotheses using variance-based structural equation modeling (PLS-SEM).

Findings- Digital technologies under the interaction effect of crisis leadership have a significant influence on the information visibility and the collaboration in the humanitarian context. The findings of the study extend the contingent resource-based views to create a better understanding of applications of digital technologies in alleviating human suffering due to crises.

Practical implications- The author provides some direction to the managers engaged in the humanitarian supply chain, contemplating using emerging technologies to enhance information visibility and collaboration.

Original/value- The current study offers some useful implications for theory. The study findings suggest that the digital technologies under the moderating effect of the crisis leadership significantly improve the information visibility and the collaboration among the emergency supply chain relief workers. These findings contribute to the contingent-resource-based view (C-RBV) literature by expanding the scope of the theory. To date, the C-RBV is yet to be explored in humanitarian or emergency settings. Further, the study empirically tests the moderating role of crisis leadership which is touted to be the game-changer, particularly in crises or emergencies.

Keywords: Digital Technologies, Crisis Leadership, Emergency Supply Chain, PLS-SEM, Information Visibility, Collaboration

1. Introduction

Digital transformation has changed the ways disaster relief efforts were carried out in the past (Dubey et al. 2019, 2021; AlHinai, 2020; Queiroz et al. 2021; Fosso Wamba, 2021), but there is a limited conceptual study that how the organizations leverage these digital technologies in the highly chaotic environment (Khan et al. 2018). In this study, the author argues digital technologies (DT) based on Warner and Wager (2019, p. 328), "*as a combination of information, computing, communication, and connectivity technologies"*. Prasanna and Haavisto (2018) argue that in an extremely chaotic environment, the collaboration among emergency relief supply chain workers holds a great promise in terms of resolving issues that may hinder emergency supply chain workers' ability to respond efficiently and effectively to tackle the crises. In the past due to the lack of information visibility, disaster relief efforts have often failed (Yates and Paquette, 2011; Fosso Wamba et al. 2019). There exist a rich body of literature on the positive influence of information visibility on supply chain performance (Wang and Wei, 2007). The role of information visibility and supply chain flexibility has played a significant role in technology-mediated integration (Wang and Wei, 2007; Williams et al. 2013; Ganesh and Kalpana, 2022). However, research focusing on the criticality of information visibility for supporting collaborative task performance in highly fragile environments, such as disasters caused by pandemics, floods, earthquakes, and geopolitical crises is scant (Fosso Wamba et al. 2021). Hence, the author argues that the organizations dealing with the emergency relief supply chains are still not clear about the relationship between digital technologies, information visibility, and collaboration. The collaboration among the emergency relief workers is often hindered due to differences in power, financial reasons, conflicting goals, or poor alignment in terms of the use of IT (Dubey et al. 2020, 2021). The author notes this as a clear research gap in the literature. To address this research gap, the author posited the first research question (RQ1): *What are the distinct and combined effects of digital technologies on information visibility and collaboration?*

Despite increasing awareness of digital technologies, emergency relief agencies remain skeptical about the potential application. Schaedler et al. (2021, p. 1) argue, "*Of all actors involved in managing an organizational crisis, strategic leaders play a particularly central role"***.** Tourish (2020) further argues the role of leadership during the COVID-19 is a point of differentiation. Salem et al. (2019) found in one of the studies, that the intergroup leadership role during disaster relief operations plays a significant role in tackling complexity resulting from the hastily formed groups often belonging to different cultures and speaking different languages, and practicing different religions. Organizational researchers have recognized the activities of the leaders or top executives in shaping organizational strategies (Hambrick and Mason, 1984). Hence, the role of leaders is especially

critical in terms of resource allocations and deployment decisions that are necessary for organizational change (Dubey et al. 2021). The author argues that the leadership perspective offers illuminating insights into operations and supply chain management literature, where resource allocations and deployment decisions may create different outcomes in dynamic and uncertain environments (see, Dubey et al. 2015; Salem et al. 2019; Dubey et al. 2021). During a time of crisis, the common citizen is in a state of confusion and helplessness due to the chaotic environment (Deitchman, 2013). With time the severity of the crisis often increases due to a lack of information visibility (Littlefield and Quennette, 2007; James et al. 2011). Those who are accountable and vested with authority are responsible for mobilizing the resources necessary to support the disaster relief efforts. As the event progresses through various stages, those in the authority must demonstrate crisis leadership to restore the normalcy and reduce the panic among the common citizens (Littlefield and Quennette, 2007; James et al. 2011; Mutch, 2015). Crisis leadership includes the following traits, " *initiating a crisis response; mitigating the harm; serving as a spokesperson; expressing sympathy to victims; framing meaning; remaining accessible and open; facilitating the flow of information; acting decisively; coordinating actions among the various response groups and agencies; reconnecting with stakeholders; maintaining decision vigilance; prioritizing activities and resources; communicating core values; paying symbolic attention to the crisis; maintaining appropriate flexibility, and facilitating renewal via public commitments",* (Littlefield and Quennette, 2007, p.30, c.f. Seeger et al. 2003, p. 250). Hence, the author suggests that in the context of the emergency supply chain, "*crisis leadership theory*" may offer useful insights to explain collaboration among members in the emergency supply chain. As a result, the role of crisis leadership in the use of DT for enhancing information visibility and collaboration among emergency supply chain workers. Liang et al. (2007) argue that the role of top managers is critical for the adoption of technology in the organization. However, despite rich literature focusing on the role of leadership in the adoption of technology, the role of crisis leadership in the adoption of digital technologies to tackle emergencies is limited. To address this research gap, the author posited a second research question (RQ2): *what are the effects of crisis leadership on the paths of joining digital technologies and information visibility/collaboration?*

To address these two research questions, the author has grounded the theoretical model in the contingent-resource-based view (C-RBV) (e.g., Aragon-Correa and Sharma, 2003). Although the RBV has been used to explain the competitive advantage of the firm relying on strategic resources, the RBV has been often criticized by scholars citing insensitivity towards context (Ling-yee, 2007; Eckstein et al. 2015). The management scholars argue that the RBV does not explain why resources under different contexts generate different values. The contingency theory (CT) is one of the most useful perspectives to understand how internal and external conditions may influence the outcome

variable. Hence, CT provides direction to the organizations to adapt to specific environmental conditions in which they exist (Sousa and Voss, 2008). To further test the research hypotheses drawn based on the C-RBV, the author gathered data from 117 NGOs in India who were involved in relief activities during the COVID-19 crisis. The authors tested the data using the variance-based structural equation modeling commercial software (Warp PLS 7.0).

The author has further organized the manuscript as follows. In section 2, the author provides the groundwork for building a theoretical framework, which seeks to explain how DT improves the information visibility and the collaboration among the emergency relief workers, under the moderating effect of intergroup leadership. Section 3 discusses our hypo-deductive research strategy, including the sampling design and data collection strategy, which resulted in data from completed questionnaires from 356 individuals working in 117 NGOs in India. The author also reports the results of non-response bias testing. In section 4 the author presents the data analyses, using PLS-SEM. Next, in section 5, the author presents a discussion of results, focusing on the implications to theory and practice. About theory development, the author describes three main contributions of the study. The author finishes section 5 with a discussion of the study limitations and some thoughts on future research directions for further work in this area. Finally, in section 6, the author concludes, finishing by stressing how the study provides an enhanced understanding of relationships between critical elements in emergency supply chains which can contribute to better management of emergency relief supply chains.

2. Theoretical Development and Hypotheses Formulation

In this study, the author underpins the theoretical model in the contingent resource-based view (C-RBV). Based on the arguments of Aragon-Correa and Sharma (2003), the C-RBV is a combination of two popular theories: RBV (Barney, 191) and contingency theory (Lawrence and Lorsch, 1967; Donaldson, 2001). Despite its immense popularity among some sections of the operations and supply chain management community (Hitt et al. 2016), the central criticism of the RBV is that it never looked beyond the properties of the resources and the resource markets to explain the firm heterogeneity (Oliver, 1997). The RBV often fails to explain the differential outcomes yielded through the bundling of the resources and capabilities. Ling-yee (2007) term this phenomenon as a context insensitivity. Context insensitivity suggests that the RBV fails to provide a better explanation or identify the conditions in which resources or capabilities may be most valuable (Brandon-Jones et al. 2014; Sedera et al. 2016). Eckstein et al. (2015) argue that the contingency theory offers an alternative theoretical lens to examine the contingent conditions under which resources and capabilities can generate better value. Donaldson (2001) uses contingency theory to

explain how organizations must adapt depending on the environmental conditions in which they operate. Sousa and Voss (2008) discuss how contingency factors, including national context and culture, firm size, strategic context, and other organizational variables, have been analyzed in operations and supply chain literature. The factor of crisis leadership has been identified as a key contingent factor. Whilst some scholars have integrated contingency theory and RBV to address the limitations of the static nature of the RBV (see, Aragon-Correa and Sharma, 2003), it is well recognized within the operations and supply chain literature that contingent perspectives of RBV in the context to crisis management are still underdeveloped (see, Ruel et al. 2021).

2.1 Theoretical Model

The theoretical model is underpinned by two theories: resource-based theory and contingency theory, with specific use of crisis leadership in respect of the latter of the two elements (see Figure 1). In this study, the author uses a resource-based perspective to explain how DT improves information visibility and collaboration among emergency supply chain workers. The visibility of information is recognized as a critical factor that supports collaboration (Caldwell et al. 2008; Dubey et al. 2018). Contingency theory explains how contingent factors like crisis leadership help to enhance the effects of DT on information visibility and collaboration. Following the preceding arguments, the author develops the theoretical model, which explains the effective and efficient use of digital technologies to improve information visibility and collaboration in the emergency relief supply chain under the moderating effect of crisis leadership.

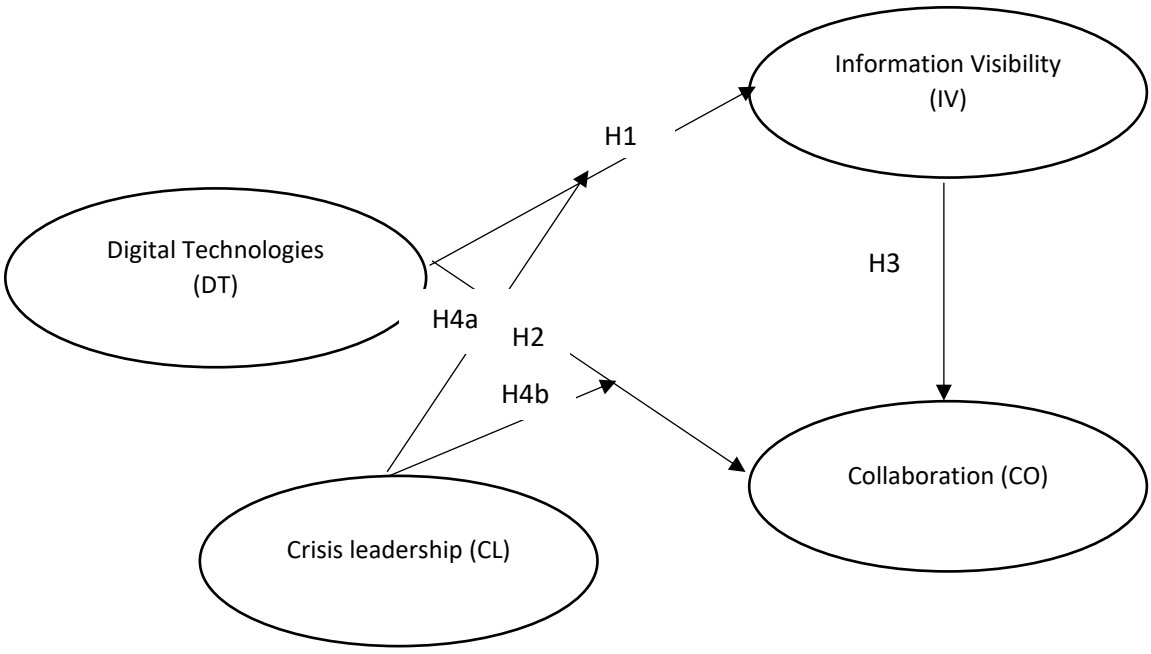


Figure 1: Theoretical Model

2.2 Research Hypotheses

2.2.1 Impact of digital technologies on Information Visibility/Collaboration

As is well established, information technology has a significant role to play in improving supply chain visibility (Wang and Wei, 2007; Bawack et al. 2021; Herold et al. 2021; Ju et al. 2021), and further help enhances collaboration (Lee et al. 1997; Cai et al. 2016). The sharing of vision, information, and resources is considered pivotal for effective and efficient disaster relief efforts (Altay and Labonte, 2014). The collaboration among the emergency supply chain workers is significantly important which determines the success or failure of disaster relief efforts (Balcik et al. 2010; Moshtari, 2016; Dubey et al. 2019). In the emergency relief supply chain, information visibility among disaster relief workers is often considered critical for better collaboration (Dubey et al. 2018). DT is fundamentally transforming the organizational strategies, the organizational capabilities, and the interfirm relationships (Warner and Wager, 2019; Khan et al. 2021). Thus, the author argues that DT and information visibility are complementary, in the sense that each demand and supports the other (Hitt, 1999; Srinivasan and Swink, 2018; Golan et al. 2021; Gligor et al. 2022). Hence, we can expect organizations involved in humanitarian activities, such as disaster relief, to understand the connections between DT, information visibility, and collaboration. The author hypothesizes these connections as:

H1: DT has a positive effect on information visibility.

H2: DT has a positive effect on collaboration.

H3: IV has a positive effect on collaboration

2.2 The Moderating Role of Crisis Leadership

In recent times the entire globe has seen a significant rise in the different forms of crises. These crises have a severe impact on the economy and organizations and thus require different kinds of leadership skills to tackle such situations that can satisfy the expectations of the various stakeholders (Wu et al. 2021). Liden and Antonakis (2009) argue that the situations often shape the leadership traits and define the approach of the leaders to tackle such crises. Thus, to explain the role of leaders during the crises such as pandemics resulting from the COVID-19 mandate the crisis leadership (Wu et al. 2021; Bastardoz et al. 2022). The growing body of rich literature on the impact of crisis leaders on tackling such situations is "…*characterized by a high degree of fragmentation,*

considerably hindering the generation of parsimonious theory and practically useful insights" (Schaedler et al. 2021, p. 1). The positive beliefs of the leaders about the usefulness of the DT during crises result in certain managerial actions that help the organizations to assimilate the DT as an integral component of their organizational design (Boin and Lodge, 2021). Based on crisis leadership theory (Littlefield and Quennette, 2007; Wu et al. 2021), the author argues that managing emergency supply chain leaders need to recognize and respect each worker's identity and must be open to innovative ideas and ways to tackle the situations favorably. Dubey et al. (2021) argue that to improve technology-mediated collaboration among disaster relief actors from diverse backgrounds, the role of leadership is highly critical, especially in the adoption of DT 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 DT and the changes imposed by the managers in the work routines. Following crisis leadership theory (see, Wu et al. 2021) the author argues that leaders cultivate unique and beneficial traits via team meetings, personal conversations, or after-work occasions, which build special bonds amongst diverse groups engaged in emergency relief operations (Stern, 2017; Sadiq et al. 2020). These traits often help leaders to resolve conflicts that are a result of a lack of visibility or transparency. In this way, we view crisis leadership plays an important role in the successful adoption of digital technologies to tackle the crises through visibility and collaboration among the emergency supply chain workers.

H4: Crisis leadership positively moderates the relationship between DT and: (a) information visibility and (b) collaboration;

2.3 Summary

The author defines the key terms used in the theoretical model and the study (see Table 1).

Table 1: Definitions

Constructs	Definition
Emergency	The Joint Staff (2012, p.4) defines an "*emergency*" as the wide array of "international conflict, humanitarian, and domestic disaster relief scenarios, involving combinations of warfare, food insecurity, epidemics, and social conflict.
Emergency Supply Chain	*The author defines emergency Supply chain management* as the planning and management of all activities involved in sourcing and procurement, and all logistics management activities to provide the right relief materials to the victims at the right time. It includes coordination with emergency relief actors, which can be suppliers, intermediaries, third-party service providers, and victims.

Digital Technologies	*Digital technologies* in this study are defined as a combination of information, communication, computing, and connectivity technologies capable of transforming business activities.
Information visibility	Wang and Wei (2007) define *Information visibility* in an emergency supply chain as the degree to which the emergency relief actors have on-hand information related to demand and supply for planning and control management of relief items.
Collaboration	Moshtari (2016, p. 1544) defines, *collaboration* as a partnership process where two or more independent organizations share resources (e.g., information, expertise, and infrastructure) or work closely to design and implement their operations.
Crisis Leadership	Firestone (2020) defined *crisis leadership* as more than simply leading an organization through the response to a crisis.

3. Research Design

The research hypotheses were tested using cross-sectional data which the author gathered from diverse participants (see Appendix A) drawn from the Indian-based NGOs involved in the relief activities to support the fragile health systems of India, especially during the second wave of the COVID-19 (early of April 2021). The author has designed the questionnaire to gather responses from the multi-respondents from the same organization to understand how the NGOs adopted various kinds of digital technologies to have clear visibility and improve collaboration among the emergency supply chain relief workers to tackle the acute shortages of the critical items. The target respondents were project directors, deputy directors, and managers from NGOs, as they are the people who were involved during the relief operations. The author initially contacted the secretary of the Ministry of Health and Family Welfare (Government of India), with the assistance of the author's contact with the senior civil servants. After assuring that the author under any circumstance will not share details provided by the Ministry of Health and Family Welfare (GoI), the office of the Ministry of Health and Family Welfare provided contact information of the NGOs involved in the relief operations during the second wave of COVID-19 in India.

3.1 Survey Instrument Development

In this study, the author has adopted two stages to develop the questionnaire (Eckstein et al., 2015; Dubey et al. 2019, 2020, 2021b) (see Appendix B). Firstly, the author undertook an extensive review of the literature published in operations management, information management, and organizational research. Existing literature was used to define the constructs and the initial list of items used for measuring each construct. Secondly, the author adapted the constructs and their associated items in the context of emergency relief settings (see, Dubey et al. 2020, 2021). The items were measured on a five-point Likert scale, with anchors ranging from strongly disagree (1) to strongly agree (5).

This scale assures high statistical variability amongst responses gathered using our structured survey-based instrument (see, Salem et al. 2019; Dubey et al. 2020, 2021) (see Appendix B).
The author undertook two steps to pre-test our instrument, to ensure that respondents would not face any difficulties in understanding the items when completing the survey (Boyer and Pagell, 2000). Firstly, the author invited 9 experts in the field of the emergency supply chain to read the first draft of the questionnaire and provide their input related to the ambiguity, clarity, and suitability of the measuring items (DeVellis, 1991; Dubey et al. 2021). Next, the author further analyzed the feedback of these researchers to understand whether the questions apply to emergency relief supply chain settings.

After refining the questionnaire based on input provided by the researchers, the author sent the questionnaire to the 33 managers from the NGOs who had extensive experience in managing supply chains of healthcare items and who had an in-depth understanding of the subject matter. The author requested these managers to provide their suggestions on the structure, readability, ambiguity, and completeness of the questions asked in the survey. After incorporating their inputs, the author has finalized the questionnaire for the data collection.

3.2 Data Collection

The author gathered the data between 27 September 2021-15 February 2022. The data were gathered from NGOs in India. The author e-mailed the questionnaires to nearly 1200 potential respondents from 365 organizations and followed up with two e-mail reminders. For this purpose, the author recruited four graduate assistants who are well familiar with the local conditions. Before data collection, the author has organized two weeks of training to understand the importance of data collection and how to politely follow up with each organization to return the responses collected from multiple respondents from each organization. The author assured the respondents that the data are collected purely for academic study and that the author will maintain anonymity. After careful examination of each response, the author eliminated cases that failed to meet the selection criteria. This usable response from 117 organizations (see Appendix A), an effective rate of 32.05 %, with at least three participants from each organization (a total of 356 multiple responses).

Although the data collection took place at one point, the author understands that the respondents may have some cognitive biases which may influence the findings of the study. The author performed wave analysis based on the guidance offered by Armstrong and Overton (1977). The author performed a t-test on data split into two parts: early wave and late wave. The results show

no significant difference between early-wave and late-wave groups of respondents (p=0.37). Thus, the author concludes that non-response bias is not a concern in the current study.

4. Data Analysis and Results

The author performed statistical analyses on data using the PLS-SEM technique to test the theoretical model and research hypotheses (Peng and Lai, 2012). In this study, the author has 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

The author has gathered data using a multi-informant questionnaire as suggested by (Ketokivi and Schroeder, 2004). Further to assess the reliability and the agreement among the responses gathered from the multiple respondents, the author performed four different methods as suggested in existing literature (see, Boyer and Verma, 2000; Ketokivi and Schroeder, 2004).

- *The percentage method (Boyer and Verma, 2000; Ketokivi and Schroeder, 2004),*
- *The ratio method (Boyer and Verma, 2000; Ketokivi and Schroeder, 2004),*
- *The inter-class correlation coefficient (Boyer and Verma, 2000)*
- *The paired t-test (Boyer and Verma, 2000; Ketokivi and Schroeder, 2004)*

The results suggest that the inter-agreement among the respondents is within the acceptable range (see, Appendix C)

4.2 Common Method Bias (CMB)

The survey-based research is likely to suffer from the common method bias (CMB), due to its design (Podsakoff et al., 2003). Despite, following the strict measures before the data collection (see, MacKenzie and Podsakoff, 2012), still the author believes that the common method bias is likely to contaminate the results. Hence, the author performs some statistical analyses to assure that the CMB is not a major concern in the current study (see, Srinivasan and Swink, 2018; Dubey et al. 2019, 2021). The author examined CMB via the correlation marker technique (Lindell and Whitney, 2001). For this, the author adopted an unrelated variable to partial out correlations caused by CMB. Additionally, following Lindell and Whitney (2001), the author assessed the significant values of correlations. The author observed minimal differences between the adjusted and

unadjusted correlations. Therefore, based on these statistical results, the author concludes that the CMB does not pose a serious concern in the present study.

To further assess the causality, which is considered one of the most important statistical tests before testing research hypotheses (see, Guide and Ketokivi, 2015) the author reported the NLBCDR (nonlinear bivariate causality direction ratio), test result (Kock, 2017). *The NLBCDR 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* (Kock, 2012, p.52-53). The threshold value should be ≥ 0.7. In the current study, the NLBCDR=0.98 (approx..) is greater than the threshold value. The result suggests that causality is not an issue in the current study. The author further provides the values for model fit and quality indices supporting this conclusion in Appendix D.

4.3 Measurement Model Reliability and Validity

In this study, the author adopted two steps to theoretically validate the model (see Figure1) following suggestions of the organizational scholars (see, Peng and Lai, 2012; Moshtari, 2016; Salem et al. 2019; Kock, 2019). Firstly, the author examined the individual factor loadings (λi), scale composite reliability (SCR), and average variance extracted (AVE) of measuring items and the constructs following Fornell and Larcker's (1981) recommendations. Table 2 shows the result of confirmatory factor analysis (CFA). The recommended threshold values are:

- factor loadings of each item ≥ 0.5;
- scale composite reliability (SCR) of each construct is ≥0.7.
- average variance extracted (AVE) of each construct is ≥0.5,

Table 2: Measurement Properties of Constructs (Convergent Validity) (N=117)

Constructs	Indicators	Factor Loadings	Variance	Error	SCR	AVE
Digital Technologies (DT)	DT1	0.88	0.77	0.23	0.94	0.77
	DT2	0.88	0.77	0.23		
	DT3	0.91	0.82	0.18		
	DT4	0.86	0.73	0.27		
	DT5	0.87	0.75	0.25		
Information Visibility (IV)	IV1	0.90	0.81	0.19	0.95	0.83
	IV2_	0.93	0.86	0.14		
	IV3	0.89	0.78	0.22		
	IV4	0.93	0.86	0.14		

Collaboration (CO)	CO1	0.93	0.87	0.13	0.95	0.84
	CO2	0.92	0.84	0.16		
	CO3	0.89	0.79	0.21		
	CO4	0.92	0.85	0.15		
Crisis Leadership (CL)	CL1	0.87	0.76	0.24	0.93	0.71
	CL2	0.79	0.63	0.37		
	CL3	0.86	0.73	0.27		
	CL4	0.84	0.71	0.29		
	CL5	0.86	0.74	0.26		

Notes: *DT, digital technologies; IV, Information Visibility; CO, Collaboration; CL, Crisis Leadership*

Secondly, the author analyzed the discriminant validity of the constructs (see Figure 1). The author further examined the rotated factor loadings matrix, which indicates that no item loads higher on another construct than it does on its associated construct i.e., the parsimonious structure (Dubey et al. 2019) (Table 3). Hence, the author concludes that the reflective measures demonstrate acceptable levels of divergent validity. Following Fornell and Larcker (1981), the author further assessed the entries of the leading diagonal matrix (see Table 4), with the inter-correlation values in the given rows and columns. The square root values of each entry of the leading diagonal, i.e., square root of AVE of construct, are greater than the inter-correlation values in each row and column in the matrix. Hence, the author concludes, that constructs possess sufficient divergent validity.

Table 3: The Rotated Matrix (parsimonious structure) (N=117)

	DT	IV	CO	CL	Type	SE	P value
DT1	0.88	-0.27	0.31	0.63	Reflect	0.074	<0.001
DT2	0.88	-0.09	-0.10	0.09	Reflect	0.074	<0.001
DT3	0.91	-0.16	0.23	0.07	Reflect	0.074	<0.001
DT4	0.86	0.22	-0.07	-0.44	Reflect	0.075	<0.001
DT5	0.87	0.32	-0.38	-0.37	Reflect	0.075	<0.001
IV1	-0.20	0.90	0.05	0.23	Reflect	0.074	<0.001
IV2_	0.11	0.93	-0.08	-0.05	Reflect	0.073	<0.001
IV3	0.02	0.89	0.16	-0.20	Reflect	0.074	<0.001
IV4	0.06	0.93	-0.12	0.02	Reflect	0.074	<0.001
CO1	-0.04	-0.03	0.93	0.08	Reflect	0.073	<0.001
CO2	-0.10	-0.09	0.92	0.14	Reflect	0.074	<0.001
CO3	-0.04	0.30	0.89	-0.27	Reflect	0.074	<0.001
CO4	0.18	-0.18	0.92	0.04	Reflect	0.074	<0.001

CL1	-0.44	0.00	0.13	0.87	Reflect	0.074	<0.001
CL2	0.10	-0.10	-0.32	0.79	Reflect	0.076	<0.001
CL3	-0.01	0.63	-0.38	0.86	Reflect	0.075	<0.001
CL4	0.14	-0.24	0.34	0.84	Reflect	0.075	<0.001
CL5	0.22	-0.30	0.21	0.86	Reflect	0.075	<0.001

Notes: *DT, digital technologies; IV, Information Visibility; CO, Collaboration; CL, Crisis Leadership (Loadings are unrotated and cross-loadings are oblique-rotated. SEs and P values are for loadings. P values < 0.05 are desirable for reflective indicators).*

Table 4: Construct Correlations (Divergent Validity) (N=117)

	DT	IV	CO	CL
DT	***0.88***			
IV	0.65	***0.91***		
CO	0.36	0.47	***0.92***	
CL	0.50	0.27	0.35	***0.84***

Notes: *DT, digital technologies; IV, Information Visibility; CO, Collaboration; CL, Crisis Leadership*

4.4 Hypotheses Testing

The hypotheses were tested using the PLS-SEM (Peng and Lai, 2019; Kock, 2019). Table 5 provides the results of the PLS-SEM analysis using the Warp PLS 7.0. The hypotheses H1-H3 examine the linkage between DT, information visibility, and collaboration. Firstly, the author found support for H1 (DT→IV) (β=0.81; $p<0.01$). Next, the author found the support for H2 (DT→CO) (β=0.43; $p<0.01$), which is consistent with previous findings in the context of big data analytics (Dubey et al. 2019). Addressing, H3 (IV→CO), the author found support (β=0.52; $p<0.01$), which is consistent with previous studies (see, Dubey et al. 2018). Overall, the results of H1-H3 reveal that the various relationships identified in other contexts hold in the emergency relief supply chain.

The author further tested the moderation effect of crisis leadership on the paths joining DT and IV/CO (H4a/b). The author found support for H4a (β=0.16; $p<0.05$) and H4b (β=0.45; $p<0.01$). The findings extend the Salem et al. (2019) and Dubey et al. (2021) findings by examining the moderating influence of crisis leadership which is far more relevant in tackling crises.

Table 5: Structural Estimates (N=117)

Hypothesis	*Effect of*	*Effect on*	*β*	*p-value*	*Results*
H1	DT	IV	0.81	<0.01	supported
H2	DT	CO	0.43	<0.01	supported
H3	IV	CO	0.52	<0.01	supported
H4a	DT*CL	IV	0.16	<0.05	supported
H4b	DT*CL	CO	0.45	<0.01	supported

Notes: *DT, digital technologies; IV, Information Visibility; CO, Collaboration; CL, Crisis Leadership*

To further examine the explanatory power of our theoretical model (see Figure 1) the author analyzed the explanatory power (R^2) of the endogenous constructs as shown in Figure 2. The R^2 of IV is 0.73 (approx.) and CO is 0.84 (approx.).

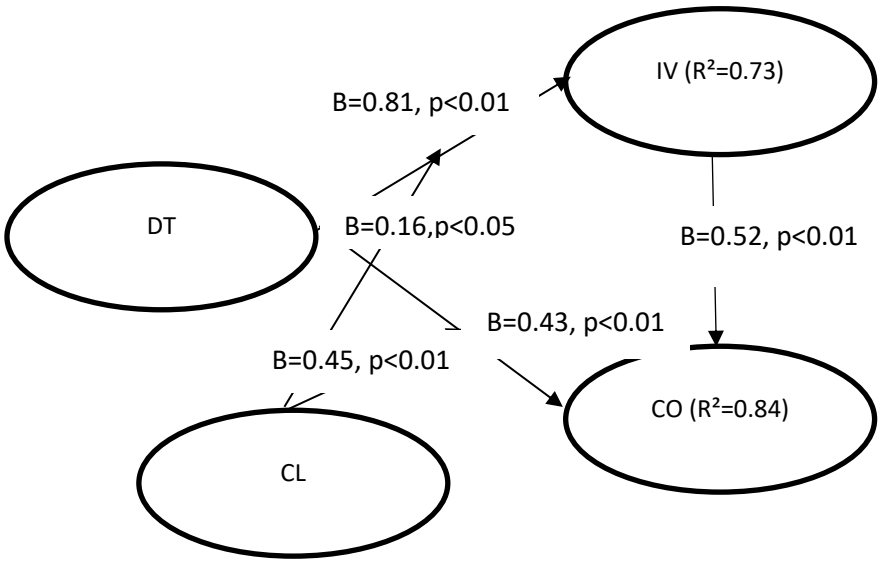


Figure 2: Final Model

The size of the effects produced in the IV by DT (0.69), CO by DT (0.37), and CO by IV (0.458). Further, we have examined the predictive relevance (Q^2) of the model which was carried out to assess the predictive capacity of the model (Peng and Lai, 2012). The predictability can be assessed

with the help of the Stone Geisser nonparametric test (Chin, 1998; Peng and Lai, 2012). The predictability of IV (0.73) and CO (0.82), which are greater than 0, indicate acceptable predictive relevance (Peng and Lai, 2012) (see, Table 6).

Table 6: R^2, Prediction (Q^2), and Effect Size (f^2)

Construct	R^2	Q^2	f^2 in relation to	
			IV	DT
IV	0.73	0.73		0.691
CO	0.84	0.82	0.458	0.373

5. Discussions

The results offer some interesting insights which broaden our understanding related to the application of digital technologies in emergency relief operations. The role of digital technologies in a commercial application is well established. However, the empirical results focusing on the application of digital technologies in improving collaboration among the various stakeholders in response to the unpredictable events having serious implications on the lives of the people are limited. Collectively, these findings as reported in Table 4 have implications for practice as well as raise some new queries that remain unresolved in the current study.

5.1 Implications to Theory

In this study, the authors present two main implications for theory. Firstly, the findings of the study help understand how the C-RBV can be a useful way to understand how resources can help improve the collaboration under the moderating influence of the crisis leadership. Although, in this study, the author is seeking to explain collaboration among the emergency relief supply chain workers. The goal of the efforts is to save the lives of the people and reduce the suffering of the victims. The RBV traditionally has its root in strategic management literature which often seeks to gain a competitive advantage over their rival firms through the exploitation of the resources that satisfy four characteristics: *valuable, rare, inimitable, and non- substitutability*. Hence, in the context of humanitarian settings, the assumptions may not hold. However, saving the lives of the people and alleviating their suffering may have a significant impact on the economy of the nation and organization. Thus, our efforts to examine the interplay between digital technologies, information visibility and collaboration under the moderating influence of the crisis leadership help expand the scope of the theory which suggests that despite the limitations of the RBV, the C-RBV can be a

useful way to explain non-profit making activities. This further extends the Aragon-Correa and Sharma (2003) arguments to include humanitarian settings.

Secondly, the technology-enabled collaboration is one of the research gaps which was not adequately addressed in the previous studies. Although in the past scholars have attempted to examine the collaboration among the disaster relief actors using a relational view. The relational view (Dyer and Singh, 1998) helps understand how relationship management can help firms to gain a competitive advantage. However, explaining collaboration among the emergency supply chain actors which are often assembled in the shortest time with no previous experience in a similar field with no or limited training is quite complex and requires a multifaceted approach. In the past scholars have made some efforts to explain the collaboration (see, Moshtari, 2016; Dubey et al. 2019, 2021), but still, the previous studies have failed to address "who" and "how" the collaboration in the humanitarian settings can be built. In the previous studies, Moshtari (2016) explained the collaboration among the humanitarian actors using the trust and commitment theory. Further, in the same study, Moshtari (2016) identified relational constructs such as compatibility, resource complementarity, and relationship management capability which are essential for building trust and commitment. However, in this study, the author seeks to explain collaboration using digital technologies. Moreover, the study further identifies the role of crisis leadership which plays a significant role in enhancing the effects of digital technologies on information visibility and collaboration. In a way, the study contributes to collaboration theory in humanitarian settings and further identifies how crisis leadership plays an integral role in building collaboration in times of crisis.

Thirdly the findings of the study distinctly contribute to the leadership traits. The role of leadership in managing disaster relief operations has attracted significant attention from the humanitarian scholars, however, to date the empirical study focusing on the traits of the leader tackling humanitarian crises are relatively less studied. Salem et al. (2019), contribute to the pending research calls by examining the role of intergroup leadership in humanitarian relief efforts. However, Deitchman (2013) noted in one of the studies that attributes of successful leaders in tackling crises of different forms require different traits. Contributing to the Deitchman (2013) arguments, the author identified traits of the leaders involved in managing the COVID-19 crisis which, is a useful contribution to the growing body of literature on crisis leadership.

In summary, the author argues that the study offers a useful contribution to the intersection of three established disciplines: information management, emergency supply chain, and organizational behavior. The emergency supply chain stems from the crises and in most cases due to a lack of

adequate resources and leadership, the emergency supply chain initiative fails. In past, scholars have made some efforts to explain the role of leadership in tackling such humanitarian crises (see, Salem et al. 2019), however, in this context, the author posits that the humanitarian supply chain or disaster relief supply chain and emergency supply chain both stems from crises. However, the humanitarian supply chain/ disaster relief supply chain includes pre-and post-disaster activities. However, the emergency supply chain is purely in response to the crises that immediately occur.

5.2 Implications to Practice

The findings of the study offer some very useful implications for the managers, who still have some doubts related to the usefulness of digital technologies in the emergency relief supply chain. It is well established that in the past most disaster relief efforts, failed (Altay and Labonte, 2014). The main reasons for such failures have been attributed to a single cause (i.e., poor coordination/ poor collaboration). Many factors hinder the successful collaboration among the disaster relief actors. Some of these factors are lack of role clarity in the actors, lack of adequate resources to tackle the crisis, and a variety of the actors involved having different backgrounds and beliefs. However, some of these challenges can be easily taken care of with the use of digital technologies (Balcik et al. 2010). The study findings further confirm the Balcik et al. (2010) arguments that the digital transformation which relies on the potential application of the digital technologies which include mobile, artificial intelligence, drone technology, data analytics tool, blockchain technology, cloud computing, and internet of things (IoT) to enable major improvement through creating more visibility in the entire chain and increasing accountability of the managers. However, to achieve desired success the role of leaders who can respond to crises play a significant role in achieving the desired success. In simple words, the author argues that in absence of the right leaders the potential benefits of the digital technologies remain limited and the return on the investment in the digital technologies may be low or insignificant. For instance, during a health crisis such as pandemics resulting from the COVID-19, the leaders require different skills such as *competence in public health crises; ability to handle media; exposure to different technologies, and a thorough understanding of the positive and negative sides of the social media; ability to coordinate diverse relief workers and the stakeholders; excellent communication skills; and the ability to build trust and motivate team members.*

5.3 Limitations and Further Research Directions

Humanitarian organizations are increasingly using digital technologies to improve information visibility and collaboration among the actors engaged in disaster relief operations. The media, common citizens, opposition parties, and international bodies are becoming less tolerant of the inefficiencies resulting during disaster relief operations, and, therefore, demanding more visibility,

accountability, and better coordination (Salem et al. 2019; Dubey et al. 2021). The study provides a nuanced understanding of technology-enabled collaboration and the role of crisis leadership in tackling complex situations resulting from crises. However, despite significant efforts to use established organizational theories and test the research hypotheses using multi-informant data gathered from NGOs engaged in the emergency relief supply chain, the author still finds some questions that remain unanswered.

Firstly, the author has focused on the application of digital technologies and information visibility, to enhance the collaboration among the actors involved in disaster relief operations. Hence future studies can explore how other organizational factors may enhance collaboration in the digital era. Additionally, the current study has not considered other potentially significant variables, such as culture or the attitude of those involved in humanitarian activities towards the usage of technologies.

Secondly, the author gathered cross-sectional data to test the research hypotheses. It is well established that the cross-sectional data has its inherent weaknesses that cannot be repaired. Hence, to tackle such studies the future study may consider the longitudinal data or can undertake a multi-level study.

Thirdly the study is grounded in the positivism philosophy. However, the hypotheses-driven research often limits the scope of the study. Hence, to address this major weakness of the current study, the author suggests adopting a multi-method approach as suggested by Boyer and Swink (2008). Following Flynn et al. (1990) notable contribution toward empirical research in operations management, the survey-based research has gained significant attention. The author appreciates the use of survey-based research to tackle the research questions, which is quite appropriate to a large extent provided that the researchers follow the rigorous methodological protocol offered by scholars (see, Flynn et al. 1990; Ketokovi and Schroeder, 2004; Guide and Ketokivi, 2015). The survey-based research is particularly very useful when the researcher is trying to deal with the behavioral constructs which only can be measured through perceptual scales. However, despite significant benefits realized using the perceptual scales, one cannot deny that the advantage comes at the cost of high measurement errors stemming from the biases of the respondents. Although empirical scholars have suggested several preventive measures and controls despite all such efforts, the potential effects of the biases cannot be repaired. Thus, to tackle some of these inherent defects of the survey-based research, future studies must embrace the multi-methods approach.

6. Conclusion

In conclusion, the findings of the study are based on the survey-based data gathered from Indian NGOs involved in disaster relief operations during the COVID-19 crisis. Digital technology has come a long way in the last few years. Digital technologies have not only played a significant role in shaping business strategies during the COVID-19 crisis but have played a significant role in alleviating human suffering. However, despite enormous potential, the potential of digital technologies in most cases remains unexplored. There could be many reasons, however, in this study, the author found that crisis leadership plays a significant role in enhancing the effects of digital technologies on improving information visibility and collaboration. The study unfolds some complex issues that often hinder the collaboration among the diverse actors engaged in the emergency supply chains. However, despite some interesting findings, the study does not provide much clarity on crisis leadership which is one of the main contributions of the study. However, this further opens new avenues for the study.

References

Altay, N., & Pal, R. (2014). Information diffusion among agents: Implications for humanitarian operations. *Production and Operations Management*, *23*(6), 1015-1027.

Altay, N., & Labonte, M. (2014). Challenges in humanitarian information management and exchange: evidence from Haiti. *Disasters*, *38*(s1), S50-S72.

Aragón-Correa, J. A., & Sharma, S. (2003). A contingent resource-based view of proactive corporate environmental strategy. *Academy of Management Review*, *28*(1), 71-88.

Armstrong, J. S., & Overton, T. S. (1977). Estimating nonresponse bias in mail surveys. *Journal of Marketing Research*, *14*(3), 396-402.

Balcik, B., Beamon, B. M., Krejci, C. C., Muramatsu, K. M., & Ramirez, M. (2010). Coordination in humanitarian relief chains: Practices, challenges and opportunities. *International Journal of Production Economics*, *126*(1), 22-34.

Bastardoz, N., Jacquart, P., & Antonakis, J. (2022). Effect of crises on charisma signaling: A regression discontinuity design. *The Leadership Quarterly*, 101590.

Bawack, R. E., Wamba, S. F., & Carillo, K. D. A. (2021). A framework for understanding artificial intelligence research: insights from practice. *Journal of Enterprise Information Management*, 34(2), 645-678.

Boin, A., & Lodge, M. (2021). Responding to the COVID-19 crisis: a principled or pragmatist approach?. *Journal of European Public Policy*, *28*(8), 1131-1152.

Boyer, K. K., & Pagell, M. (2000). Measurement issues in empirical research: improving measures of operations strategy and advanced manufacturing technology. *Journal of Operations Management*, *18*(3), 361-374.

Boyer, K. K., & Verma, R. (2000). Multiple raters in survey-based operations management research: a review and tutorial. *Production and Operations Management*, *9*(2), 128-140.

Boyer, K. K., & Swink, M. L. (2008). Empirical elephants—why multiple methods are essential to quality research in operations and supply chain management. *Journal of Operations Management*, *26*(3), 338-344.

Brandon-Jones, E., Squire, B., Autry, C. W., & Petersen, K. J. (2014). A contingent resource-based perspective of supply chain resilience and robustness. *Journal of Supply Chain Management*, *50*(3), 55-73.

Cai, Z., Huang, Q., Liu, H., & Liang, L. (2016). The moderating role of information technology capability in the relationship between supply chain collaboration and organizational responsiveness: evidence from China. *International Journal of Operations & Production Management*, 36(10), 1247-1271.

Caldwell, B. S., Palmer III, R. C., & Cuevas, H. M. (2008). Information alignment and task coordination in organizations: An 'information clutch' metaphor. *Information Systems Management*, *25*(1), 33-44.

Cao, M., & Zhang, Q. (2011). Supply chain collaboration: Impact on collaborative advantage and firm performance. *Journal of Operations Management*, *29*(3), 163-180.

Chin, W. W. (1998). The partial least squares approach to structural equation modeling. *Modern Methods for Business Research*, *295*(2), 295-336.

Deitchman, S. (2013). Enhancing crisis leadership in public health emergencies. *Disaster Medicine and Public Health preparedness*, *7*(5), 534-540.

DeVellis, R. F. (1991). Guidelines in scale development. *Scale Development: Theory and Applications. Newbury Park, Calif: Sage.*

Dubey, R., Singh, T., & Gupta, O. K. (2015). Impact of agility, adaptability and alignment on humanitarian logistics performance: mediating effect of leadership. *Global Business Review*, *16*(5), 812-831.

Dubey, R., Luo, Z., Gunasekaran, A., Akter, S., Hazen, B. T., & Douglas, M. A. (2018). Big data and predictive analytics in humanitarian supply chains: Enabling visibility and coordination in the presence of swift trust. *International Journal of Logistics Management*, *29*(2), 485-512.

Dubey, R., Gunasekaran, A., Childe, S. J., Roubaud, D., Wamba, S. F., Giannakis, M., & Foropon, C. (2019). Big data analytics and organizational culture as complements to swift trust and collaborative performance in the humanitarian supply chain. *International Journal of Production Economics*, *210*, 120-136.

Dubey, R., Gunasekaran, A., Bryde, D. J., Dwivedi, Y. K., & Papadopoulos, T. (2020). Blockchain technology for enhancing swift-trust, collaboration and resilience within a humanitarian supply chain setting. *International Journal of Production Research*, *58*(11), 3381-3398.

Dubey, R., Bryde, D. J., Foropon, C., Tiwari, M., Dwivedi, Y., & Schiffling, S. (2021). An investigation of information alignment and collaboration as complements to supply chain agility in humanitarian supply chain. *International Journal of Production Research*, *59*(5), 1586-1605.

Donaldson, L. (2001). *The contingency theory of organizations*. Sage.

Dwivedi, Y. K., Shareef, M. A., Mukerji, B., Rana, N. P., & Kapoor, K. K. (2018). Involvement in emergency supply chain for disaster management: a cognitive dissonance perspective. *International Journal of Production Research*, *56*(21), 6758-6773.

Dyer, J. H., & Singh, H. (1998). The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review*, *23*(4), 660-679.

Eckstein, D., Goellner, M., Blome, C., & Henke, M. (2015). The performance impact of supply chain agility and supply chain adaptability: the moderating effect of product complexity. *International Journal of Production Research*, *53*(10), 3028-3046.

Firestone, S. (2020). What is crisis leadership?. In *Biblical Principles of Crisis Leadership* (pp. 7-21). Palgrave Macmillan, Cham.

Flynn, B. B., Sakakibara, S., Schroeder, R. G., Bates, K. A., & Flynn, E. J. (1990). Empirical research methods in operations management. *Journal of Operations Management*, *9*(2), 250-284.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18*(1), 39-50.

Fosso Wamba, S., Edwards, A., & Akter, S. (2019). Social media adoption and use for improved emergency services operations: The case of the NSW SES. *Annals of Operations Research*, *283*(1), 225-245.

Fosso Wamba, S., Queiroz, M. M., Roscoe, S., Phillips, W., Kapletia, D., & Azadegan, A. (2021). Emerging technologies in emergency situations. *International Journal of Operations and Production Management*, *41*(9), 1405-1416.

Fosso Wamba, S. (2020). Humanitarian supply chain: A bibliometric analysis and future research directions. *Annals of Operations Research*, 1-27.DOI: 10.1007/s10479-020-03594-9.

Gligor, D. M., Davis-Sramek, B., Tan, A., Vitale, A., Russo, I., Golgeci, I., & Wan, X. (2022). Utilizing blockchain technology for supply chain transparency: A resource orchestration perspective. *Journal of Business Logistics*, *43*(1), 140-159.

Golan, M. S., Trump, B. D., Cegan, J. C., & Linkov, I. (2021). Supply chain resilience for vaccines: review of modeling approaches in the context of the COVID-19 pandemic. *Industrial Management & Data Systems*, *121*(7), 1723-1748.

Guide Jr, V. D. R., & Ketokivi, M. (2015). Notes from the Editors: Redefining some methodological criteria for the journal. *Journal of Operations Management*, *37*(1), v-viii.

Gunasekaran, A., Dubey, R., Fosso Wamba, S., Papadopoulos, T., Hazen, B. T., & Ngai, E. W. (2018). Bridging humanitarian operations management and organisational theory, *International Journal of Production Research*, 56(21), 6735-6740.

Hambrick, D. C., & Mason, P. A. (1984). Upper echelons: The organization as a reflection of its top managers. *Academy of Management Review*, *9*(2), 193-206.

Herold, D. M., Ćwiklicki, M., Pilch, K., & Mikl, J. (2021). The emergence and adoption of digitalization in the logistics and supply chain industry: an institutional perspective. *Journal of Enterprise Information Management*, *34*(6), 1917-1938.

Hitt, M. A., Carnes, C. M., & Xu, K. (2016). A current view of resource-based theory in operations management: A response to Bromiley and Rau. *Journal of Operations Management*, *41*(10), 107-109.

James, E. H., Wooten, L. P., & Dushek, K. (2011). Crisis management: Informing a new leadership research agenda. *Academy of Management Annals*, *5*(1), 455-493.

Joint Staff, J. (2012). Operation of the Logistics Enterprise in Complex Emergencies. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.250.8984&rep=rep1&type=pdf (Date of access: 5th May 2022).

Ju, Y., Hou, H., & Yang, J. (2020). Integration quality, value co-creation and resilience in logistics service supply chains: moderating role of digital technology. *Industrial Management & Data Systems*, *121*(2), 364-380.

Ketokivi, M. A., & Schroeder, R. G. (2004). Perceptual measures of performance: fact or fiction?. *Journal of operations management*, *22*(3), 247-264.

Khan, M. N., Akhtar, P., & Merali, Y. (2018). Strategies and effective decision-making against terrorism affecting supply chain risk management and security: A novel combination of triangulated methods. *Industrial Management & Data Systems*, *118*(7), 1528-1546.

Khan, S. A. R., Yu, Z., Umar, M., de Sousa Jabbour, A. B. L., & Mor, R. S. (2021). Tackling post-pandemic challenges with digital technologies: an empirical study. *Journal of Enterprise Information Management*, 35(1),36-57.

Kock, N. (2012). WarpPLS 5.0 user manual. *Laredo, TX: ScriptWarp Systems*.

Kock, N. (2017). Common method bias: A full collinearity assessment method for PLS-SEM. In *Partial least squares path modeling* (pp. 245-257). Springer, Cham.

Kock, N. (2019). From composites to factors: Bridging the gap between PLS and covariance-based structural equation modelling. *Information Systems Journal*, *29*(3), 674-706.

Krishnan, R., Martin, X., & Noorderhaven, N. G. (2006). When does trust matter to alliance performance?. *Academy of Management journal*, *49*(5), 894-917.

Lawrence, P. R., & Lorsch, J. W. (1967). Differentiation and integration in complex organizations. *Administrative Science Quarterly*, 12(1),1-47.

Li, Q., Wang, C., Wu, J., Li, J., & Wang, Z. Y. (2011). Towards the business–information technology alignment in cloud computing environment: anapproach based on collaboration points and agents. *International Journal of Computer Integrated Manufacturing*, *24*(11), 1038-1057.

Liang, H., Saraf, N., Hu, Q., & Xue, Y. (2007). Assimilation of enterprise systems: the effect of institutional pressures and the mediating role of top management. *MIS Quarterly*, *31*(1), 59-87.

Liden, R. C., & Antonakis, J. (2009). Considering context in psychological leadership research. *Human Relations*, *62*(11), 1587-1605.

Ling-Yee, L. (2007). Marketing resources and performance of exhibitor firms in trade shows: A contingent resource perspective. *Industrial Marketing Management*, *36*(3), 360-370.

Lindell, M. K., & Whitney, D. J. (2001). Accounting for common method variance in cross-sectional research designs. *Journal of Applied Psychology*, *86*(1), 114-114.

Littlefield, R. S., & Quenette, A. M. (2007). Crisis leadership and Hurricane Katrina: The portrayal of authority by the media in natural disasters. *Journal of Applied Communication Research*, *35*(1), 26-47.

Lee, H. L., Padmanabhan, V., & Whang, S. (1997). Information distortion in a supply chain: The bullwhip effect. *Management Science*, *43*(4), 546-558.

MacKenzie, S. B., & Podsakoff, P. M. (2012). Common method bias in marketing: Causes, mechanisms, and procedural remedies. *Journal of Retailing*, *88*(4), 542-555.

McIsaac, J., Brulle, J., Burg, J., Tarnacki, G., Sullivan, C., & Wassel, R. (2019). Blockchain

Moshtari, M. (2016). Inter-organizational fit, relationship management capability, and collaborative performance within a humanitarian setting. *Production and Operations Management*, *25*(9), 1542-1557.

Mutch, C. (2015). Leadership in times of crisis: Dispositional, relational and contextual factors influencing school principals' actions. *International Journal of Disaster Risk Reduction*, *14*, 186-194.

Ng, I. C., Ding, D. X., & Yip, N. (2013). Outcome-based contracts as new business model: The role of partnership and value-driven relational assets. *Industrial Marketing Management*, *42*(5), 730-743.

Oliver, C. (1997). Sustainable competitive advantage: combining institutional and resource-based views. *Strategic Management Journal*, *18*(9), 697-713.

Ozdemir, A. I., Erol, I., Ar, I. M., Peker, I., Asgary, A., Medeni, T. D., & Medeni, I. T. (2021). The role of blockchain in reducing the impact of barriers to humanitarian supply chain management. *The International Journal of Logistics Management*, *32*(2), 454-478.

Peng, D. X., & Lai, F. (2012). Using partial least squares in operations management research: A practical guideline and summary of past research. *Journal of Operations Management*, *30*(6), 467-480.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies. *Journal of Applied Psychology*, *88*(5), 879-903.

Prasanna, S. R., & Haavisto, I. (2018). Collaboration in humanitarian supply chains: an organisational culture framework. *International Journal of Production Research*, *56*(17), 5611-5625.

Reich, B. H., & Benbasat, I. (2000). Factors that influence the social dimension of alignment between business and information technology objectives. *MIS Quarterly*, *24*(1), 81-113.

Queiroz, M. M., & Fosso Wamba, S. (2021). A structured literature review on the interplay between emerging technologies and COVID-19–insights and directions to operations fields. *Annals of Operations Research*, 1-27. DOI: 10.1007/s10479-021-04107-y.

Rosenthal, R. (1991). If you're looking at the cell means, you're not looking at only the interaction (unless all main effects are zero). *Psychological Bulletin*, *110*(3), 574-576.

Ruel, S., El Baz, J., Ivanov, D., & Das, A. (2021). Supply chain viability: conceptualization, measurement, and nomological validation. *Annals of Operations Research*, 1-30. DOI: 10.1007/s10479-021-03974-9.

Sadiq, A. A., Kapucu, N., & Hu, Q. (2021). Crisis leadership during COVID-19: the role of governors in the United States. *International Journal of Public Leadership*, *17*(1), 65-80.

Salem, M., Van Quaquebeke, N., Besiou, M., & Meyer, L. (2019). Intergroup leadership: How leaders can enhance performance of humanitarian operations. *Production and Operations Management*, *28*(11), 2877-2897.

Schaedler, L., Graf-Vlachy, L., & König, A. (2021). Strategic leadership in organizational crises: A review and research agenda. *Long Range Planning*, 102156.

Sedera, D., Lokuge, S., Grover, V., Sarker, S., & Sarker, S. (2016). Innovating with enterprise systems and digital platforms: A contingent resource-based theory view. *Information & Management*, *53*(3), 366-379.

Seeger, M. W., Sellnow, T. L., & Ulmer, R. R. (2003). Communication and organizational crisis. Westport, CN: Praeger.

Simatupang, T. M., & Sridharan, R. (2005). The collaboration index: a measure for supply chain collaboration. *International Journal of Physical Distribution & Logistics Management*, 35(1),44-62.

Stern, E. K. (2017). Crisis, leadership, and extreme contexts. In *Leadership in Extreme Situations* (pp. 41-59). Springer, Cham.

Sousa, R., & Voss, C. A. (2008). Contingency research in operations management practices. *Journal of Operations Management*, *26*(6), 697-713.

Srinivasan, R., & Swink, M. (2018). An investigation of visibility and flexibility as complements to supply chain analytics: An organizational information processing theory perspective. *Production and Operations Management*, *27*(10), 1849-1867.

Tan, K. C., Kannan, V. R., Hsu, C. C., & Leong, G. K. (2010). Supply chain information and relational alignments: mediators of EDI on firm performance. *International Journal of Physical Distribution & Logistics Management*, 40(5), 377-394.

Tenenhaus, M., Vinzi, V. E., Chatelin, Y. M., & Lauro, C. (2005). PLS path modeling. *Computational statistics & data analysis*, *48*(1), 159-205.

Tourish, D. (2020). Introduction to the special issue: Why the coronavirus crisis is also a crisis of leadership. *Leadership*, *16*(3), 261-272.

Wang, E. T., & Wei, H. L. (2007). Interorganizational governance value creation: coordinating for information visibility and flexibility in supply chains. *Decision Sciences*, *38*(4), 647-674.

Warner, K. S., & Wäger, M. (2019). Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal. *Long Range Planning*, *52*(3), 326-349.

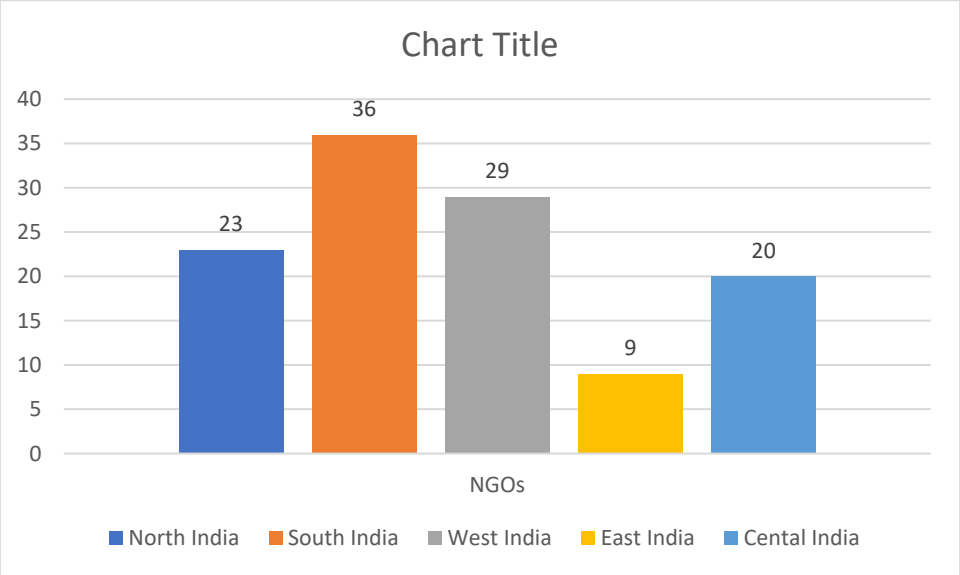
Williams, B. D., Roh, J., Tokar, T., & Swink, M. (2013). Leveraging supply chain visibility for responsiveness: The moderating role of internal integration. *Journal of Operations Management*, *31*(7-8), 543-554.

Wu, Y. L., Shao, B., Newman, A., & Schwarz, G. (2021). Crisis leadership: A review and future research agenda. *The Leadership Quarterly*, *32*(6), 101518.

Yates, D., & Paquette, S. (2011). Emergency knowledge management and social media technologies: A case study of the 2010 Haitian earthquake. *International Journal of Information Management*, *31*(1), 6-13.

Yong, B., Shen, J., Liu, X., Li, F., Chen, H., & Zhou, Q. (2020). An intelligent blockchain-based system for safe vaccine supply and supervision. *International Journal of Information Management*, *52*, 102024.

Appendix A: Demographic Profile of the responding organizations (N=117)



Appendix B: Operationalisation of constructs

Construct and Derivation	**Types**	**Measures**
Digital Technologies (DT) (Adapted and modified from Warner and Wager, 2019)	Reflective	Our organization use information extracted using machine learning tools for making decisions (DT1) Our organization uses digital track systems to track the vaccine distribution (DT2) Our organization coordinates with the relief workers using WhatsApp/ Facebook/ Instagram (DT3) Our organizations use AI-driven analytics techniques to plan for the inventory of vaccines, PPEs, oxygen cylinders, and bed capacity in the hospital (DT4) Our organization uses a digital payment system (DT5)
Information Visibility (IV) (adapted from Wang and Wei, 2007; Dubey et al. 2018)	Reflective	Our organization completely shares the tracking details of the vaccines with the relief workers, government officers, the health department, and the district magistrate's office (IV1) Our organization shares the details of the covid affected victims with the relief workers, government officers, the health department, and the district magistrate's office (IV2) Our organization regularly communicates our future strategic needs among the disaster relief workers (IV3) Our organization creates compatible information systems among the relief workers, government officers, the health department, and the district magistrate's office (IV4)

Collaboration (CO) (Krishnan et al. 2006; Moshtari, 2016; Dubey et al. 2021)	Reflective	The objectives for which the collaboration among the relief workers, government officers, the health department, and the district magistrate's office established are being met (CO1) Our organization is satisfied with the overall performance of the collaboration (CO2) Our association with the relief workers, government officers, the health department, and the district magistrate's office has been a successful one (CO3) The relief workers, government officers, the health department, and the district magistrate's office seem to be satisfied with the overall performance of the collaboration (CO4)
Crisis Leadership (CL) (Littlefield and Quennette, 2007)	Reflective	The field manager continuously interacts with the workers to understand their problems (CL1) The media manager continuously interacts with the selected media houses to provide them with accurate information to prevent panic among the common citizens (CL2) The field manager plays a significant role in promoting digital technologies to create transparency and collaboration among the workers and the stakeholders (CL3) The field manager immediately took necessary actions to provide relief materials to the hospitals (CL4) The field manager immediately took the necessary steps to handle the COVID-19 affected serious patients in remote locations (CL5)

Appendix C: Measures of inter-rater agreement (N=117)

Constructs	Percentage method (%)	Ratio method	Inter-class correlation coefficient	Paired t-test
DT	89	0.92	0.28	Not-significant
IA	87	0.89	0.38	Not-significant
CO	86	0.91	0.35	Not-significant
CL	89	0.94	0.39	Not-significant

Notes: *DT, digital technologies; IV, Information Visibility; CO, Collaboration; CL, Crisis Leadership*

Appendix D: Model fit and quality indices (N=117)

Model fit and quality indices	Value from analysis	Acceptable if	Reference
APC	0.37, $p<0.001$	$p<0.05$	Rosenthal and Rosnow (1991)

ARS	0.79, $p<0.001$	$p<0.05$	
AVIF	3.054	≤ 5	Kock (2012)
Tenenhaus GoF	0.81	Large if ≥ 0.36	Tenenhaus et al. (2005)