Blockchain technology for enhancing swift-trust, collaboration and resilience within a humanitarian supply chain setting

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Abstract

There has been tremendous interest in blockchain technology (BT) (also known as distributed ledger technology) around the globe and across sectors. Following significant success in the financial sector, other sectors, such as humanitarian sector, have started deploying BT at various levels. Although the use of BT in the humanitarian sector is in its infancy, donors and government agencies are increasingly calling for building BT-enabled swift-trust and more collaborative relationships among various humanitarian actors in order to improve the transparency and traceability of disaster relief materials, information exchanges and flow of funds in disaster relief supply chains. Our study, which is informed by organizational information processing theory and relational view, proposes a theoretical model to understand how BT can influence operational supply chain transparency (OSTC) and swift-trust (ST) among actors engaged in disaster relief operations. Our model also shows how BT-enabled ST can further improve collaboration (CO) among actors engaged in disaster relief operations and enhance supply chain resilience. We formulated and tested six research hypotheses, using data gathered from international non-governmental organizations (NGOs) with the help of the Coordinator for Humanitarian Affairs (OCHA) database. We received 256 usable responses using a pre-tested survey based instrument designed for key informants. Our results confirm that our six hypotheses were supported. Our study offers significant and valid contributions to the literature on swift-trust, collaboration and supply chain resilience and BT/distributed ledger technology. We have also noted limitations of our study and have offered future research directions.

Key words: *blockchain technology, distributed ledger technology, humanitarian supply chain management, humanitarian operations management, swift-trust, collaboration, supply chain resilience, operational supply chain transparency*

1. Introduction

Disasters and crises are complex and very challenging for organizations involved in disaster relief operations (Gibson and Tarrant, 2010; Gunasekaran et al. 2018). Increasingly natural disasters are affecting the lives of the people. For instance, earthquakes and tsunamis accounted for the majority of the 10,373 lives lost in 2018, while extreme weather adversely affected nearly 61.7 million people (UNISDR, 2019). These events suggest that volatility in our natural, economic and social systems appears to be increasing at a faster rate than many organisations and societies can cope with. Hence in recent years, a majority of developing economies have been either deliberately designed, or have evolved, to operate efficiently and effectively in routine environments characterized by stability and predictability (Gibson and Tarrant, 2010; Zhang et al. 2019; Ivanov and Dolgui, 2019). Despite a high level of preparation, one of the most powerful earthquakes and tsunami in 2011, which was triggered by 9.0 Mw (moment magnitude scale) along the northern Pacific coast of Japan (Nakanishi et al. 2014; Koshimura and Shuto , 2015 ; Aoki, 2016), caused potential damage to lives and properties. Similarly, the 2010 Haiti earthquake or 2018 Kerala floods resulted in many lessons to be learned that have led to a paradigm shift in ways post-disaster relief efforts were managed. Given the high number of humanitarian relief actors engaged in post-disaster relief efforts, the lack of collaboration (CO) (Moshtari, 2016; Islam and Walkerden, 2017; Dubey et al. 2019a) and high levels of corruption (Islam and Walkerden, 2017; Dwivedi et al. 2018) among these humanitarian organizations (HOs), there is often poor distribution of relief materials to the affected areas, particularly in the last mile; causing congestion at local airports and roads. This can even lead to competition among these humanitarian actors over limited resources (e.g., building materials, medicine, labor etc.,) raising costs and causing delay (Chang et al. 2011; Moshtari, 2016; Awasthy et al. 2019). To address these challenges, the humanitarian actors are increasingly calling for more collaborative relationships and enhanced resilience in disaster relief supply chains via emerging technologies (Ko and Verity, 2016; Dubey et al. 2019a; Chen et al. 2019). Improved CO within a humanitarian setting can yield benefits, such as access to more resources (e.g., donations, equipment, skills and information) (Moshtari, 2016; Wagner and Thakur-Weigold, 2018) and further enhance resilience (Wieland and Marcus Wallenburg, 2013; Dubey et al. 2019b).

CO is one of the areas within the operations management field that has attracted significant attention. It is well understood that CO has a positive impact on organizational performance (Cao and Zhang, 2011). It enables organizations to achieve competitive advantage by reducing costs and improving service levels, as well as enabling quick responds to any changes in the environment (Stank et al. 2001; Tsou, 2013). However, successful CO among the actors engaged in disaster relief operations is based on the level of the actor's commitment (Moshtari, 2016; Dubey et al. 2017, 2019). Ralston et al. (2017) argue that the factors that impede successful CO are: differences in power, financial reasons, conflicting goals or poor alignment in terms of use of IT. Casey and Wong (2017) further argue that lack of trust and transparency in information sharing among supply chain partners often leads to poor CO. In humanitarian settings the lack of trust and visibility are often cited as the main reasons behind poor CO among humanitarian actors (Moshtari, 2016; Dubey et al. 2019a). These problems are often due to a large number and variety of actors, a chaotic post-disaster relief environment and the lack of sufficient resources (Balcik et al. 2010; Moshtari, 2016). Hence, blockchain technology (BT) is put forward as a technology that may change organization cultures, supply chains and industries (Kewell et al. 2017; Min, 2019; Zhu et al. 2019; Zhu and Kouhizadeh, 2019; Saberi et al. 2019; Queiroz and Wamba, 2019; Dolgui et al. 2019; Wang et al. 2019a, 2019b). Due to increasing interest in bitcoin, the BT application that powers cryptocurrency concept and provides the underlying technology has gained heightened interest among scholars, policy makers and business communities (Min, 2019; van Hoek, 2019). In general, BT allows for safe financial transactions between two or more actors involved in supply chain networks via a digital decentralized ledger, which cannot be interfered with (Dolgui et al. 2019). In fact many organisations, like Maersk (Lal and Scott, 2018) and Walmart in cooperation with IBM (Yadav and Singh, 2020), have implemented BT in their organizations. Moreover, some scholars argue that BT has great potential to shape disaster relief supply chains (see, Thomason et al. 2018; Chen, 2018; Ramadurai and Bhatia, 2019), though the development and the implementation of BT solutions in humanitarian settings are still at an early stage.

In the past scholars have argued that lack of trust among the partners in supply chain was a major issue because CO requires information sharing of sensitive data and requires visibility in supply chain (Barratt, 2004; Ramanathan, 2014; Ramanathan and Gunasekaran, 2018; Dubey et al. 2018a; Mejia et al. 2019). However, except for anecdotal evidences, the existing literature has remained silent on the role of BT, which allows actors to share information in a completely safe and transparent way, with the result of enabling swift-trust (ST) amongst those engaged in disaster relief operations. Scholars in the past have studied the direct relationship between ST and CO among the actors engaged in disaster relief operations (Tatham and Kovacs, 2010; Lu et al. 2018; Dubey et al. 2019a). However, research into the mediating role of ST between BT and CO is in its infancy. Finally, understanding of the effects and interrelationships of BT, operational supply chain transparency (OSTC) and ST remains fragmented and lacks adequate theoretical grounding. Hence, the main objective of our research is to understand how the application of BT can build ST, enhance

CO and increase SCR. Hence, our first research question is: *what are the distinct and combined effects of BT and OSTC on ST?*

Understanding of the concept of supply chain resilience (SCR) is in its infancy stage; it was first defined from an organisational perspective in case of supply chain management in the early 2000's (Hohenstein et al. 2015; Tabaklar, 2017). Although, the term resilience has been studied in other fields for considerably longer, such as materials science, ecological sciences and organizational research (Pettit et al. 2013). Despite increasing literature on SCR, there is still no common definition of the concept (Gunasekaran et al. 2015; Tukamuhabwa et al. 2015; Chowdhury and Quaddus, 2017; Ivanov et al. 2018; Ivanov and Sokolov, 2019). Following Ponomarov and Holcomb's (2009, p.131) definition, we argue that SCR is " *the adaptive capability of the supply chain that prepare it to deal with unexpected events, respond to disruptions and further help to recover from disruptions via maintaining continuity of operations at desired level of connectedness and control over structure and function*". Currently, studies in SCR have emerged that discuss more thoroughly the role of procurement (Pereira et al. 2014; Vanpoucke and Ellis, 2019; Kaur and Singh, 2019), the role of trust (Soni et al. 2014; Jain et al. 2017; Dubey et al. 2019b), the role of flexibility (Ivanov et al. 2014; Kamalahmadi and Parast, 2016; Chowdhury and Quaddus, 2017; Sreedevi and Saranga, 2017; Dubey et al. 2019c), the role of cooperation/collaboration (Christopher and Peck, 2004; Wieland and Marcus Wallenburg, 2013; Scholten and Schilder, 2015; Dubey et al. 2019b), the role of supply chain visibility (Brandon-Jones et al. 2014), and the role of emerging technologies like big data and predictive analytics (Dubey et al. 2019c; Singh and Singh, 2019; Ivanov et al. 2019) & blockchain technology (Min, 2019).

To build resilient supply chains, there are diverse capabilities that need to be in place (Tabaklar, 2017; Sa et al. 2019; Hosseini and Ivanov, 2019; Elluru et al. 2019). However, humanitarian supply chains involve various actors with different skills coming together from different organisations to achieve a common goal: to help people and alleviate suffering. Despite a common goal, the CO efforts among the actors are often challenging due to barriers resulting from geography, different cultural backgrounds and different organizational policies (Balcik et al. 2010). Moreover, the unpredictability and surges in demand, coupled with scant resources, are the main characteristics of the humanitarian settings (Balcik and Beamon, 2008; Kovacs and Spens, 2009; Altay and Labonte, 2014; Altay and Pal, 2014; Altay et al. 2018; Ni et al. 2019). Hence, scalability is an important characteristics of humanitarian supply chains, as the design of humanitarian supply chains must be flexible enough to accommodate sudden change in demand during disaster relief operations (Day, 2014; Tabaklar, 2017; Singh et al. 2019). Moreover, to achieve scalability in humanitarian supply chains, it is important to build ST among actors involved in disaster relief operations (Tatham and Kovacs, 2010; Dubey et al. 2019a) and CO (Moshtari, 2016) via information sharing (Altay and Pal, 2014). In this study we focus on ST and CO as antecedents of SCR. Research has shown that ST and CO may severely impact upon certain humanitarian supply chain management characteristics (i.e., Tatham and Kovacs, 2010; Dubey et al. 2017; Lu et al. 2018; Dubey et al. 2018, 2019a). However, such crucial effects have not been addressed by prior research theoretically or been subjected to empirical testing. For, instance Min (2019) argue that BT can be effectively utilized to reduce supply chain disruptions and may help to enhance SCR. However, in the context of humanitarian settings, evidence of the potential of BT still remains elusive. The extant literature provides anecdotal evidence (Ramadurai and Bhatia, 2019), yet empirical study is scant. We note this as a significant research gap and hence we specify our second research question as: *what are the direct and combined effects of ST and CO on SCR?*

We answer our two research questions using data collected from respondents in 256 international non-governmental organizations engaged in disaster relief operations in countries across Asia, Europe, Africa, North America and South America. To provide theoretical arguments to interpret our empirical results, we used an integration of organizational information processing theory (OIPT) (see, Gattiker and Goodhue, 2004; Haußmann et al. 2012; Srinivasan and Swink, 2015, 2018; Dubey et al. 2019a, 2019c) and relational view (Dyer and Singh, 1998), because neither perspective can, on its own, explain the direct or mediating roles of BT, OSTC, ST and CO on SCR. Our paper is organized as follows. In section 2 we present the underpinning theory of our study, theoretical model and our research hypotheses. In section 3 we illustrate our research design, including a detailed discussion on the operationalization of our constructs, sampling design and data collection strategy. In section 4 we present our data analyses. In section 5 we provide our discussion of the results and implications to theory and practice, the limitations of our study and future research directions.

2. Theoretical model and hypotheses development

The foundation of our theoretical model is grounded in two perspectives: organizational information processing theory (OIPT) and relational view (RV). In recent years OIPT has emerged as a powerful explanation of how information is used effectively to gain competitive advantage, especially when organizations execute tasks that involve a high degree of uncertainty (Galbraith, 1974; Srinivasan and Swink, 2015, 2018; Zhu et al. 2018; Dubey et al. 2019a, 2019c). Following Galbraith (1971, 1977) we argue that an organization can either reduce their needs for information via mechanistic approaches or increase their information processing capability. The first option, i.e., reducing its information processing need via creating slack resources/ or by creating self-contained tasks, may prove costly and does not contribute to agility. The second option, i.e., increasing information processing capability of the organization via investing in both lateral and vertical information systems, is perhaps a better option in uncertain environments (Srinivas and Swink, 2018). Hence, we argue that increasing information visibility may help to enhance ST among the actors engaged in disaster relief operations (Dubey et al. 2019a). In addition an organization utilising its strong technological capability will not have much effect on the organizational behavior without also affecting the behavior of the humans engaged in the process. Thus we argue, based on RV, that ST and CO amongst the actors involved in disaster relief operations play a significant role in enhancing resilience in humanitarian supply chains. The RV suggests that an organization can derive their competitive edge via relational rents or benefits that are created within collaborative relationships and through the joint effort and contribution of the partners (Dyer and Singh, 1998; Wang et al. 2013; Moshtari, 2016), which may not be feasible through the effort of a single organization (Cao and Zhang, 2011). Hence, we propose our theoretical model informed by two organizational perspectives: OIPT and RV (see Figure 1).

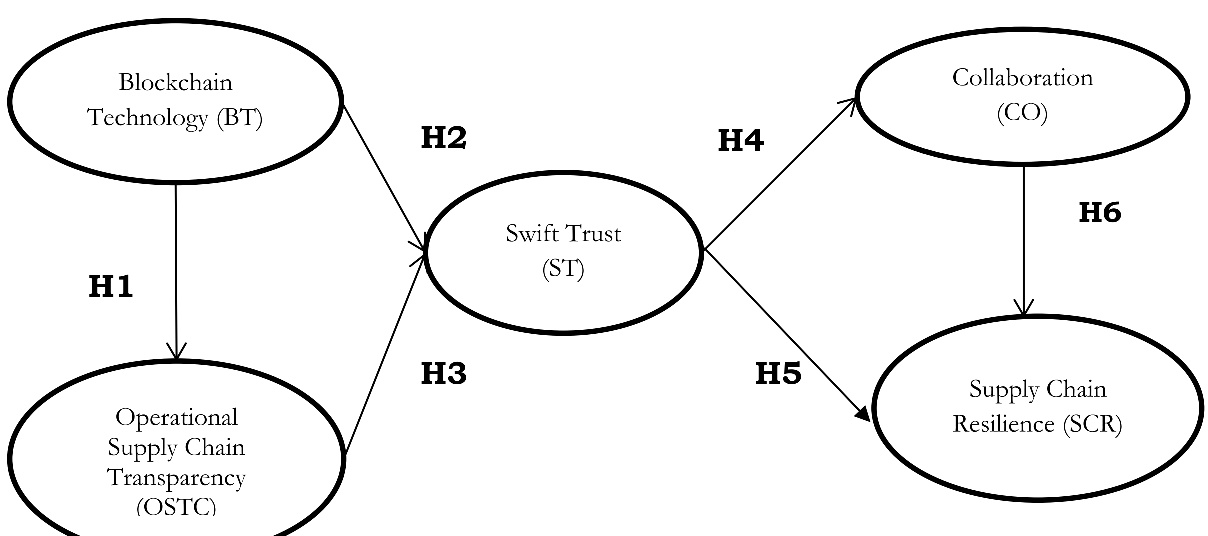

Figure 1: Theoretical Model

2.1 Blockchain technology and operational supply chain transparency

Zhu et al. (2018) argue that transparent supply chain relies heavily on flow of materials, fund and related information in entire chain. Morgan et al. (2015) further defined operational supply chain transparency (OSCT) as an "*organization's capability to proactively engage in communication with stakeholders to create visibility and traceability into upstream and downstream supply chain operations*", (c.f. Zhu et al. 2018, p. 48). In simple words we can explain OSCT help the supply chain partners in a supply chain to track current and historical activities of products throughout the entire supply chain. Hence, we can argue that transparency in supply chain help to reduce complexity of supply chain processes via improving visibility of upstream and downstream supply chain operations (Brandon-Jones et al. 2014). Dolgui et al. (2019) argue that BT is a hack-resistant, tamper-proof and immutable due to its distributed ledger and network verification process. Hence, due this characteristics BT offers traceability, since append-only distributed databases of previous transaction records can be shared across the entire partners to partner's network and the historical records remain forever with permanent footprints (Min, 2019; Martinez et al. 2019; Roeck et al. 2019). We have further illustrated the use of BT particularly in humanitarian sector based on Ko and Verity (2019) works (see, Appendix A). Thus, we can argue that BT can be successfully utilized for improving OSCT. Hence, we can hypothesize it as:

H1: BT is positively related to OSTC;

2.2 Blockchain technology and swift-trust

Altay and Labonte (2014) argue that unreliable information and information silos among humanitarian actors is often considered as a key barrier in coordination among the humanitarian actors. In the era of big data, the role of information sharing play a critical role in effective and efficient disaster response (Dubey et al. 2018). Casey and Wong (2017) further argue that BT can help to overcome barriers that impede data sharing via providing an information that is publicly accessible to all users while preserving the information security. This may further help to reduce the costs and increase transparency with humanitarian data (Solaiman and Verity, 2019). Thus due to blockchain's distributed ledger technology, it is possible for different humanitarian actors engaged in disaster relief operations to collect and share data on the same network. Hence, we can argue that BT offers a permanent, searchable, irrevocable public records repository. Thus a combination of time-stamped and digitally verified information hosted on an accessible ledger, may help to build rapid trust among the various actors involved in disaster relief operations. Thus we can hypothesize it as:

H2: BT is positively related to swift-trust;

2.3 Operational supply chain transparency and swift-trust

Akkermans et al. (2004) argue that transparency in supply chain has positive impact on trust. Although, this is well studied by organisational scholars (see, Anderson and Narus, 1990), the empirical study is limited. Anderson and Narus (1990) found that the past information exchange between two companies, has played an important role in building trust. Korsgaard et al. (1995) found that those organisations had more transparency in terms of rules, on procedural justice, it further resulted into higher degree of trust and commitment. Kwon and Suh (2004) further argues that behavioral uncertainty often arises from lack of adequate information sharing or transparency among the partners in the supply chain has large effect on the governance. The behavioral uncertainty created by any supply chain partner will decrease the trust in other partners. Dubey et al. (2017) further examined how information sharing among the actors involved in disaster relief operations further reduces the behavioral uncertainty and build ST. Hence, based on preceding discussions, we can argue that OSTC created via BT can further help to build ST among humanitarian actors. Thus we hypothesize it as:

H3: OSTC is positively related to swift-trust;

2.4 Swift-trust and collaboration;

The CO in the context to humanitarian setting has gained immense attention from operations management scholars (Moshtari, 2016; Prasanna and Haavisto, 2018; Dubey et al. 2019a). However, the theory of humanitarian supply chain collaboration heavily rely on traditional supply chain collaboration theory. The supply chain collaboration in supply chain management literature has been grouped into two categories (Cao and Zhang, 2011): relationship-based (Bowersox et al., 2003) and process-driven (Mentzer et al., 2001). Relationship-based collaboration is often seen as a long-term partnerships in which partners actively share information and strategic resources to achieve a common goal. On the other hand, process-driven collaboration occurs when two or more organizations engage to achieve common goals (Moshtari, 2016; Prasanna and Haavisto, 2018;

Dubey et al. 2019a). Based on Morgan and Hunt (1994), we extend the underlying proposition (i.e., trust and commitment) leads to CO. One aspect of the Morgan and Hunt (1994) argument is the amount of trust among partners. According to Morgan and Hunt (1994, p.23), trust is defined as "confidence *in an exchange partner's reliability and integrity*". Moshtari (2016, p. 1545) argue that in a humanitarian context, "*humanitarian organisation's trust in its partner can be observed via openness between partners/or greater appreciations of partners' contributions towards building collaborative relationship".* Hence, due to high level of competition among organizations for limited resources in humanitarian context, the mutual trust helps to minimize the opportunistic behaviors, and encourages partners' to exchange information, knowledge and other resources with each other (Moshtari, 2016; Dubey et al. 2017; Salem et al. 2019). Dubey et al. (2017) have found positive association between ST among humanitarian actors engaged in disaster relief operations and level of coordination. Hence, relying on previous findings we hypothesize it as:

H4: Swift-trust is positively related to collaboration;

2.5 Swift-trust and supply chain resilience

Blackhurst et al. (2011) argue that relationship competencies such as communication, relationship management and monitoring systems are positively related to resilience. Relying on previous arguments that relational view offers useful explanation to SCR theory (see, Wieland and Marcus Wallenburg, 2013; Johnson et al. 2013; Papadopoulos et al. 2017; Dubey et al. 2019b).Dubey et al. (2019b) have found positive association between trust and SCR. Hence, relying on previous arguments we argue that ST among the actors engaged in disaster relief operations will have positive influence on SCR. Hence, we hypothesize it as:

H5: Swift-trust is positively related to supply chain resilience;

2.6 Collaboration and supply chain resilience

Scholten and Schilder (2015) have found in their study that CO is one of those essential capabilities which have positive influence on building SCR. The CO between supply chain partners enables the bonding among partners, facilitates joint planning and encourages real time information exchange (Juttner and Maklan, 2011), needed for quick recovery from disasters while reducing their negative impacts (Altay et al. 2018). Barratt (2004) further argue that mutual respect and sharing of benefits, rewards and risk coupled with effective and efficient information exchange between partners are the founding pillars of the CO. Hence, it well understood based on literature review that CO among partners bring several benefits such as higher visibility, flexibility and further reduces lead times (Cao and Zhang, 2011; Scholten and Schilder, 2015). Relying on these essential characteristics of collaboration, we can argue that CO among disaster relief actors may help to enhance SCR. Thus, we can hypothesize it as:

H6: Collaboration is positively related to supply chain resilience;

We include several control variables in our statistical analyses, which may affect the mediating factors in our theoretical model. Following Moshtari (2016) arguments, we have controlled the interdependency perception. Hibbard et al. (2001) argue that interdependence enhances the desire to maintain the relationship. Moreover, we control for the temporal orientation. Collaboration requires long term investment in terms of human resources and information. Hence long term orientation has significant positive impact on successful collaboration (Morgan and Hunt, 1994), particularly when degree of uncertainty is high. Moreover, long term orientation helps to enhance mutual trust among partners.

3. Research design

3.1 Survey instrument development

To test our six-research hypotheses, we first defined our constructs and generated our items via critical review of literature published in organizational studies and operations management. Secondly, we adapted them to fit clearly in context to humanitarian operations management (Moshtari, 2016; Dubey et al. 2019a; Salem et al. 2019). To further assess the clarity of items used in survey based instrument and their proper adaptation in context to humanitarian settings, we requested seven humanitarian or disaster relief operations practitioners to fill out the questionnaire in front of the researcher who attended 4th French National Humanitarian Conference (Paris 22nd March, 2018) and to raise any concerns found within. For instance, we asked these experts to have their view on the clarity and appropriateness of the measures purporting to tap the constructs. We adopted a seven point Likert scales with end points "*strongly disagree*" and "*strongly agree*" to measure the items of all latent variables and capture responses for all items. Based on this we examined the content validity of constructs and their related measuring items (see Appendix B).

3.2 Sampling design

Since, the empirical context of our study is based on international NGO's engaged in disaster relief operations in various countries across Asia, Europe, Africa, North America and South America. The constructs which we used in our study are grounded to examine the relationship between organizations, viewed from focal organization's perspective. Informed by Lambe et al. (2002) and Moshtari (2016) works, our measures were based on perceptions of one key informant. We identified the key informants with the help of the Coordinator for Humanitarian Affairs (OCHA) database. The contact information of all these international NGOs were gathered with the help of OCHA leadership team. We ensured that the respondents were knowledgeable about the applications of emerging technologies in disaster relief operations with the help of OCHA team. The guidance of OCHA team in this context was highly appreciable as they provided us database about those NGOs who are using BT, big data analytics and artificial intelligence in disaster relief operations or are planning to adopt.

3.3 Data collection

We started data collection via e-mail based on Dillman's (2007) tailored design method. In recent years, scholars have adopted Dillman's total design test method to improve the response rate (see, Rothaermel and Alexandre, 2009; Cao and Zhang, 2011; Eckstein et al. 2015; Moshtari, 2016; Dubey et al. 2019a, b, c). We started our data collection in the month of September, 2018 and the data collection lasted till February, 2019. We contacted 1713 respondents via e-mail with package consisting of invitation letter which clearly explained the purpose of our study and we assured each participants that we will maintain strict anonymity and confidentially about their information. After three e-mail reminders we received 256 usable responses with an effective response rate (14.94%). This response rate is low as our respondents were NGOs and most of respondents were yet to understand the role of BT in their context. Moreover, our response rate is in the line of other similar studies (e.g., 13% Moshtari (2016) or 23% Salem et al. (2019)). The participants involved in our study were senior managers in their organizations (logistics/supply chain/procurement head or Director or CEO). The profile of the participants were shown in Appendix B. Our respondents were [23.44% from NGOs managing health services, 30.47 from NGOs managing logistics services, 21.88 % from NGOs managing food security, 16.02% from NGOs managing water, sanitation and hygiene and 8.2% from NGOs managing camp coordination]. Moreover, respondents were from 26 counties across five continents (see Appendix C).

We tested response bias following Armstrong and Overton (1977) arguments. We compared the responses of each measurement item between early responses (first 30%) to late responses (last 30%). This test assumes that the late respondents are equivalent to non-respondents (Armstrong and Overton, 1977). We found no statistically significant differences (for every measurement item we observed $p>0.25$), between early and late respondents in responses for all measurement items. Hence, we can argue that non-response bias do not pose major concern in our study.

4. Data analysis

We first tested our measurement items for the assumption of constant variance, existence of outliers and normality. Further, to ensure that multi-collinearity is not a major problem, we calculated variance inflation factors (VIF). In our case all VIF were less than 3.0, and therefore significantly below recommended threshold of 10.0 (Hair et al. 2006). Hence, we can argue that multi-collinearity is not a major issue in our study.

4.1 Measurement properties of constructs

Table 1 reports coefficient alphas (α), scale composite reliabilities (SCR) and average variance extracted (AVE) for the study's first-order, multi-item constructs. The values derived indicate reliable and valid measures of the individual constructs. After examining the construct validity individually, we performed a confirmatory factor analysis (CFA) with the help of AMOS 22.0 (Liang and Yang, 2018) and the maximum likelihood procedures (Hair et al. 2006). The measures of goodness of fit had satisfactory results [$\chi^2/df=1.74$; CFI= 0.97; GFI=0.92; TLI=0.93; RMSEA=0.03].

Table 1: Measurement Scales

Items	*Lambda*	*Variance*	*Error*	*Alphas*	*SCR*	*AVE*
BT1	0.89	0.79	0.21	0.93	0.94	0.77
BT2	0.89	0.80	0.20			
BT3	0.89	0.79	0.21			
BT4	0.86	0.73	0.27			
BT5	0.87	0.75	0.25			
OSTC1	0.89	0.79	0.21	0.90	0.93	0.77
OSTC2	0.88	0.77	0.23			
OSTC3	0.84	0.70	0.30			

OSTC4	0.90	0.81	0.19			
ST1	0.91	0.82	0.18	0.87	0.92	0.80
ST2	0.91	0.82	0.18			
ST3	0.87	0.75	0.25			
CO1	0.89	0.78	0.22	0.87	0.92	0.80
CO2	0.89	0.79	0.21			
CO3	0.91	0.83	0.17			
SCR1	0.86	0.74	0.26	0.88	0.92	0.74
SCR2	0.88	0.78	0.22			
SCR3	0.84	0.70	0.30			
SCR4	0.85	0.73	0.27			
I1	0.93	0.87	0.13	0.80	0.93	0.87
I2	0.93	0.87	0.13			
LTO1	0.91	0.83	0.17	0.91	0.94	0.84
LTO2	0.93	0.87	0.13			
LTO3	0.90	0.82	0.18			

Notes: BT, blockchain technology; OSTC, operational supply chain transparency; ST, swift trust; CO, collaboration; SCR, supply chain resilience; I, interdependence; LTO, long term orientation

Next, we have examined discriminant validity of the constructs used in our study (see Table 2). Following, Fornell and Larcker (1981) arguments, we compared the square root of AVE of each construct with the absolute value of the correlation of that factor's measure with all measures of other factors in the model, as reported in Table 2.

Table 2: Descriptive Statistics and discriminant validity

	SCALE RANGE	**MEAN**	**SD**	**BT**	**OSTC**	**ST**	**CO**	**SCR**	**I**	**LTO**
BT	1-7	5.26	0.94	*0.88*						
OSTC	1-7	4.91	0.87	0.28	*0.88*					
ST	1-7	5.72	1.08	-0.07	-0.22	*0.89*				
CO	1-7	5.65	1.06	-0.08	-0.06	0.29	*0.89*			
SCR	1-7	5.63	1.04	-0.04	0.04	-0.22	-0.12	*0.86*		
I	1-7	3.42	0.88	0.39	0.18	-0.13	-0.20	0.09	*0.93*	
LTO	1-7	3.21	0.58	-0.06	-0.15	0.09	0.09	0.03	-0.12	*0.92*

Notes: BT, blockchain technology; OSTC, operational supply chain transparency; ST, swift trust; CO, collaboration; SCR, supply chain resilience; I, interdependence; LTO, long term orientation

4.2 Common method bias

The use of key informants is in common in organizational research (see, Schilke, 2014; Moshtari, 2016; Srinivasan and Swink, 2018; Fosso Wamba et al. 2019), common method bias might create problem in some studies (see, Podsakoff et al. 2003; Ketokivi and Schroeder, 2004). Hence, to avoid such possibility, we followed several steps. Firstly, and most importantly we gathered collaboration and supply chain resilience response in a separate survey. This technique is known as split survey method. Eckstein et al. (2015) argue that split survey method reduces the likelihood of common method bias. Secondly, we performed Harman's one factor test via loading all the measurement items of our study into an exploratory factor analysis (EFA). The maximum variance explained by a single factor is 42.78 %, suggesting that common method bias was unlikely to contaminate our study. Thirdly, we applied the marker variable test (Lindell and Whitney, 2001) which attempts to control for common method variance via including a variable to the measurement model that is theoretically unrelated to the main constructs used in our model. By performing this test, we have not noted any potential effects that would indicate a significant amount of common method variance (CMV). These findings in total indicated that common method bias is not a serious issue in our study. Following Guide and Ketokivi (2015) arguments, we have performed endogeneity test via conducting Durbin-Wu-Hausman test (see, Davidson and MacKinnon, 1993). In recent years, operations management scholars have shown increasing interests in performing endogeneity test (see, Dong et al. 2016; Liu et al. 2016; Dubey et al. 2018b) to address causality problems that is often found in studies when researchers use non-experimental data to test their research hypotheses. The empirical scholars engaged in operations management research often use non-experimental data collected over a period (i.e., cross-sectional data). For, this we have first regressed BT and OSTC on ST, then used the residual of this regression output as an additional regressor in our hypothesized equations. We found that parameter estimate for the residual was not significant. Similarly, we regressed ST over CO and SCR, and then used the residual of the regression output as an additional regressor. We found that parameter estimate for the residual was not significant. Hence, we draw conclusion that BT and OSTC were not endogenous in our setting. Similarly, we also conclude that ST is not endogenous to CO and SCR. Next, we have performed our hypotheses tests.

4.3 Hypotheses tests

We examined our research hypotheses via hierarchical regression analysis. Two models, each for ST (M1), and SCR (M2), were tested. In M1 we tested the direct impacts of BT and OSTC on ST. In M2 we tested the direct effects of the ST on CO and SCR. We controlled the effects of control variables of our study. Table 3 summarizes the regression analyses results for M1 and M2 respectively.

Table 3: Hierarchical regression results (n=256)

VARIABLES	MODEL 1 (DV=ST)	MODEL 2 (DV=SCR)
CONTROLS		
I		-0.017 (p=0.643)
LTO		-0.053 (p=3.320)
PATHS		
BT→OSTC	0.69 (p=0.000)	
OSTC→ST	0.63 (p=0.000)	
BT→ST	0.98 (p=0.000)	
ST→CO		0.86 (p=0.000)
ST→SCR		0.862 (p=0.000)
CO→SCR		0.41 (p=0.000)
R^2	0.575	0.797

Notes: BT, blockchain technology; OSTC, operational supply chain transparency; ST, swift trust; CO, collaboration; SCR, supply chain resilience; I, interdependence; LTO, long term orientation

As we discussed in the beginning of our section 4, that we noted highest VIF=3.0. This clearly suggests that multi-collinearity is not an issue in our study (Hair et al. 2006). In case of Model 1 we have found support for H1 (BT→OSTC) (β=0.69, p=0.000). We can argue that BT has positive and significant effect on OSTC. H2 (BT→ST) (β=0.98, p=0.000), indicates that our initial assumption informed via review of academic literature and practitioner reports, found support. We can argue based on our regression results that BT has significant effect on building ST. Although, extant literature and reports have clearly advocated this argument. However, to our understanding, based on review of literature, it was not clear that how use of BT can help to build swift-trust among the actors involved in disaster relief operations. For, H3 (OSTC→ST) (β=0.63, p=0.000), we found support. Hence, we can argue that OSTC has positive and significant effect on ST. Overall, the predictors BT and OSTC, explain nearly 57.5 % (R^2=0.575) of the total variance in ST. This indicates that BT and OSTC are strong predictors of ST.

Similarly, in case of model M2 we have found support for hypotheses H4 (ST→CO) (β=0.86, p=0.000), H5 (ST→SCR) (β=0.862, p=0.000) and H6 (CO→SCR) (β=0.41, p=0.000). These results clearly suggests that ST developed among the humanitarian actors has positive significant effects on CO and SCR. Moreover, CO among the humanitarian actors has significant positive effect on SCR. Overall, the ST and CO together explain nearly 79.7% of the total variance in SCR (R^2=0.797). Thus we can argue that ST and CO are the strong predictors of the SCR in humanitarian relief supply chain.

5. Discussion of results and implication to theory and practice

The operations management literature broadly conceptualizes distributed ledger technology as a technologically enabled ability that allows anyone to transfer assets-including intangible assets-without the risk of hacking and building silos that limit interactions among trading partners. In addition to the security benefit, the distributed ledger technology further reduces transaction cost, improves visibility across the supply chain and further enhances coordination among the partners (Min, 2019; Roeck et al. 2019; Dolgui et al. 2019), thereby enabling organizations to gain competitive advantage (Hughes et al. 2019). We further expand the definition to include the inter-organization and process elements of distributed ledger technology, positioning from an organizational information processing theory and relational view perspective, ensuring safe transaction in entire supply chain is both a challenge and an opportunity. In humanitarian context, the data sharing, donor financing, cash programmes and crowdfunding, always remained a serious challenge (Mejia et al. 2019). Rarely, humanitarian non-governmental organizations rely on "mechanistic" approach to take decisions via rules, hierarchy, targets and goals (Dubey et al. 2019a). Instead, humanitarian non-governmental organizations need to process large data of quality information stored in data warehouse to take quick decisions (Altay and Labonte, 2014; Altay and Pal, 2014). To reduce, the distortion of information and create transparency in entire humanitarian supply chain, organizations need infrastructure and processes that may enable to exchange information without any distortion among all the key partners involved in disaster relief operations. Hence, the information exchanged via increased information processing ability without fear of distortion of information can reduce behavioral uncertainty, especially when disaster relief teams are hastily formed and the scenario in which the hastily formed teams are highly volatile and operational tasks are highly complex (i.e, highly interdependent). These basic characteristics of disaster relief operations have renewed relevance, considering the large number of humanitarian actors coming from different cultural background and beliefs. Hence, informed via literature and reports, we view BT as a kind of distributed ledger technology as belonging to specific case of information processing capabilities, made possible by recent growth in technologies, which are embedded in organizational and processes. Hence, in this study we have examined the associations between blockchain technology and operational supply chain transparency and their effects on building swift-trust among the actors engaged in disaster relief operations. Hence, to address this we have posited our first research question. The empirical results of our study has confirmed the validity of existing strands of theory regarding trust and transparency (Akkermans et al. 2004) This in itself may be seen a significant contribution to the literature, as previous research efforts have clearly called for empirical validation of trust created via distributed ledger technology (Min, 2019; Roeck et al. 2019; Dolgui et al. 2019). Moreover, our results further support the need for technology enabled swift-trust among the disaster relief actors (Dubey et al. 2019a) and to further improve transparency and traceability of funds in disaster relief chains (Mejia et al. 2019).

Next, we further examined the relational orientation (technology enabled swift-trust and collaboration) as an informal governance between humanitarian actors engaged in disaster relief operations. To address this concern we posited our second research question. The results obtained via data analyses, we confirm that there exist a significant association between swift-trust and collaboration. This findings of our study further support Moshtari (2016) findings. Moreover, our study further empirically validate the claim of previous studies (see, Roeck et al. 2019; Dolgui et al. 2019; Hughes et al. 2019). Our results are quite consistent with previous trust-commitment theory (Morgan and Hunt, 1994). Further, informed by previous research (see, Wieland and Marcus Wallenburg, 2013; Dubey et al. 2019b) we examined the influence of relational competencies on supply chain resilience. Informed by Dyer and Singh (1998) relational view, we examined the effects of technology enabled swift-trust and collaboration on supply chain resilience. Scholten and Schilder (2015) argue that the literature focusing on collaboration and supply chain resilience is rich. However, it is little known that how collaboration influences supply chain resilience. Moreover, to our knowledge, the literature have remained silent on the combined effects of swift-trust and resilience. Hence, our results based on data, we confirm that collaboration and swift-trust are significant predictors of supply chain resilience. Thus we can argue that these results offer unique contribution to literature which have either studied the relationship between trust and resilience or collaboration and resilience. Moreover, previous theoretical propositions empirical validation was a clear research gap. Hence, via this study we confirm that swift-trust and collaboration have a significant influence on supply chain resilience. Hence, our results are consistent with the relation view of Dyer and Singh (1998) and Wieland and Marcus Wallenburg (2013). Table 4 provides a summary of the evidence of our data provides in support or non-support of the research hypotheses generated in our study. Collectively, these findings have implications for theory and practice in this emerging field.

Table 4: Summary of hypotheses tests

Hypothesis	*Expected relationship*	*Supported?*
H1	BT is positively associated with OSTC	Yes
H2	BT is positively associate with ST	Yes
H3	OSTC is positively associated with ST	Yes
H4	ST is positively associated with CO	Yes
H5	ST is positively associated with SCR	Yes
H6	CO is positively associated with SCR	Yes

Notes: BT, blockchain technology; OSTC, operational supply chain transparency; ST, swift trust; CO, collaboration; SCR, supply chain resilience; I, interdependence; LTO, long term orientation

5.1 Contributions to theory

Based on our results, we can argue that our study offers some useful contributions to theory. Firstly, there is an agreement in the literature that swift-trust is one of the formative elements of the collaboration, to date little is known that how swift-trust can be developed. Tatham and Kovacs (2010) argue that swift-trust is essential for bringing temporary teams formed with clear purpose and common task with a finite life span. Dubey et al. (2019a) found a strong and positive association between big data analytics capability and swift-trust. Hence, informed by this study we further examined the role of distributed ledger technology in building swift-trust. Altay and Labonte (2014) argue that humanitarian supply chains are extremely dynamic. As a result, supply chain visibility and data tracing can often be challenging (Altay and Pal, 2014; Mejia et al. 2019). Hence, increasing transparency can greatly enhance trust-among the actors engaged in disaster relief operations. Thus our empirical results clearly suggest that BT offers a way to improve transparency in humanitarian supply chains and further build swift-trust. These findings clearly support organizational information processing theory. Secondly, our results further widens our conceptual understanding of supply chain resilience; on the other hand, it further expand our knowledge about the technology enabled relational competences recommended for supply chains designed for post disaster relief operations. Our work further empirically tested the points raised by previous scholars (see, Min, 2019) in humanitarian settings. Our findings suggest that BT is an organisational capability, which has positive effects on transparency, swift-trust and collaboration which in totality have significant and positive effect on humanitarian supply chain resilience. Thus our efforts further refine the previous understanding of the role of emerging technologies in improving humanitarian supply chains design to improve the efficiency and effectiveness of the post-disaster relief efforts. These findings of our study further confirm Wang et al. (2013) arguments related to integration of information processing view and relational view.

5.2 Contributions to practice

Our study echo the points raised by Fisher et al. (2019). The primary objective of our study is to provide directions to the managers engaged in disaster relief efforts and are either using emerging technologies or contemplating to use emerging technologies like BT in disaster relief efforts. In an attempt we have grounded our study in theory and used survey data to test our research hypotheses. Hence, we have attempted to answer some questions that often confuse managers engaged in disaster relief efforts as: when to use BT? And secondly, how does it help to improve the disaster relief efforts?. In past most of the studies have offered anecdotal evidences and lack theory and data driven studies that may help to answer some of the pending research calls. Our results offer some interesting directions to the policy makers or the managers engaged in disaster relief operations. As we understand that logistics efforts nearly account 80% of disaster relief operations (see, Jahre et al. 2007). Hence, visibility, accountability and traceability remains a major concerns in these disaster relief supply chains. Moreover, humanitarian organizations are increasingly handling volumes of sensitive information related to their donors. Moreover, there is a dilemma among the stakeholders that to what extent these new technologies help to preserve the information. Thus our empirical results offer immense guidance that investment in BT not only offer security to the information exchange, it further improves swift-trust and collaboration among the actors engaged in disaster relief operations. Moreover, distributer ledger technology may help to improve donor financing and crowd funding capabilities. Thus we can argue that BT could enable humanitarian actors to better control the distribution aid, and ensure that funds reach the right victims, in right time via lowering transaction cost and publicly monitoring the flow of disaster relief materials, information and fund, the resilience of humanitarian supply chains can be improved.

5.3 Limitations of our study and further research directions

Informed by Barratt and Oke (2007) arguments, we submit that the competitive advantages stem from the ways in which such technologies are used, rather from the technologies themselves. Hence, as with any study, the results of our study should be cautiously evaluated in the light of its limitations. Based on the legal structure of our organizations in our sample and related confidentiality requirements concerning information about their partners and donors, we did not have the ability to collect sufficient amount of data, which would have been desirable, especially in context to the role of the organizational culture on the effects of BT and OSTC on swift-trust. However, our limitation can offer an opportunity to further extend our theory. Hence, in future the interaction effect of the organizational culture can be examined on the paths connecting BT, OSTC and ST. Moreover, we have collected data which is based on perception of an individual. Although, previous studies have shown strong association between perceptual based study and actual study (Dess and Robinson Jr., 1984); however in future the objective measures can provide better insights. Moreover, the subjective measures often suffer from common method bias. Despite of several measures we undertook to minimize the effects of common method bias, we argue that the data gathered from multiple respondents may be useful (see, Ketokivi and Schroeder, 2004). Further research may examine the non-linear effects of BT on OSTC/ST. Since, our study is informed by previous assumptions, the linear assumption may not hold good in dynamic environment (Fosso wamba et al. 2019). Finally, it is worth noting that use of single method may not provide complete insights (Craighead and Meredith, 2008). Hence, we argue that there is need for mixed-methods research (Boyer and Swink, 2008) or alternative methods like (e.g., cross-sectional or longitudinal studies, well-structured single or multiple case studies, field studies or lab experiment) to further explore the linkages between BT and OSTC/ST/CO/SCR among disaster relief organizations.

6. Conclusion

Blockchain technology (which is also known as distributed ledger technology) being considered as a transformative technology with potential to increase transparency and building trust in supply chain across various industries. The technology has potential to play a critical role in enhancing collaboration via building swift-trust among various actors engaged in disaster relief operations. Our study aimed at providing initial understanding of application of this distributed ledger technology in humanitarian supply chain via addressing two research questions: *what are the distinct and combined effects of BT and OSTC on ST?*; and *what are the direct and combined effects of ST and CO on SCR?* . The purpose of this study was accomplished by developing a conceptual model based on organizational information processing theory and relational view, which was empirically tested using data gathered from 256 respondents from international non-governmental organizations (NGOs) engaged in disaster relief operations. The findings provide evidence in support of proposed conceptual model, which demonstrates that BT exerts positive and significant influence on operational supply chain transparency and they both together significantly influences building swift-trust that in turn has significant and positive influence on both collaboration and supply chain resilience. Given the critical role of trust, collaboration and supply chain resilience in handling global challenges such as disaster relief operations, this study has made significant useful contributions by establishing role of BT in facilitating them. Hope, this paper provide enough food of thought.

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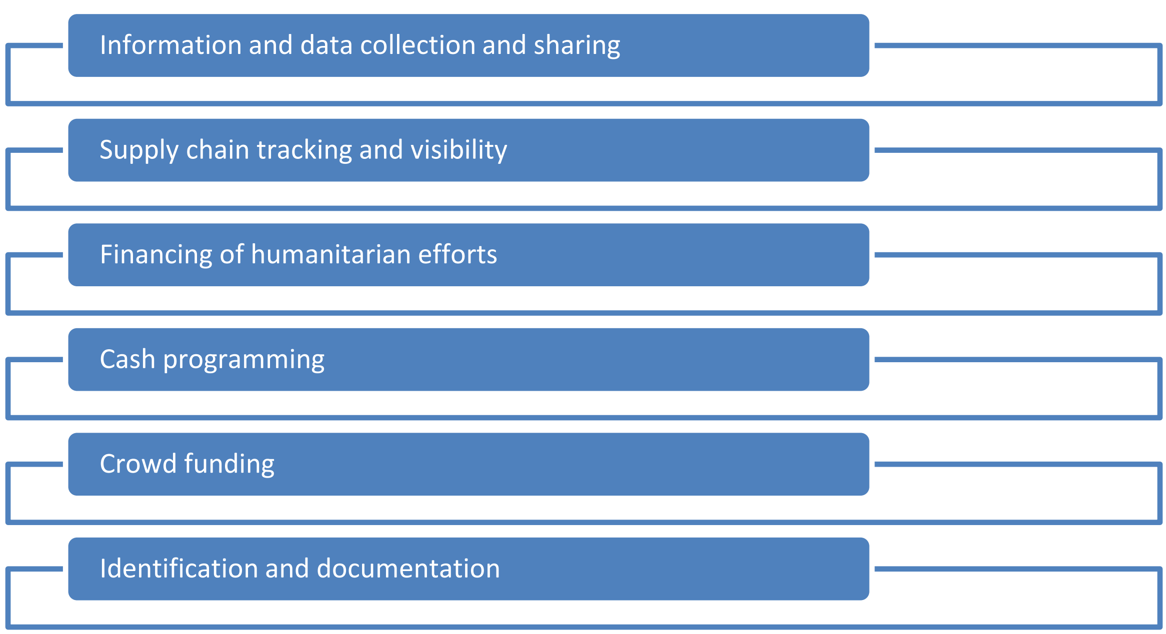
Appendix A: Use of BT in Humanitarian Supply Chain



Adapted from Ko and Verity (2019)

Appendix B: Construct Operationalization

Construct	*Types*	*Relevant Literature*	*Survey items*
Blockchain Technology (BT)	Reflective	Hughes et al. (2019);	1. We use distributed ledger technology to share information during disaster relief operations (BT1) 2. We use distributed ledger technology as it help to maintain confidentiality, integrity and availability of the data (BT2) 3. We use distributed ledger technology to improve transparency in disaster relief supply chain (BT3) 4. We routinely use distributed ledger technology as a data platform that traces the origins, use and destination of humanitarian supplies (BT4) 5. We routinely use distributed ledger technology to avoid unreliable information to avoid confusion among partners engaged in disaster relief operations (BT5)
Operational Supply Chain Transparency (OSTC)	Reflective	Zhu et al. (2018)	1. We routinely share our operational plans (i.e., distribution and storage plans) (OSTC1) 2. Our partners routinely gather strategic information related to disaster affected areas (OSTC2) 3. Our partners routinely share strategic information (OSTC3) 4. Our local partners share their strategic information related to local culture, government regulations and other useful information (OSTC4)
Swift-Trust (ST)	Reflective	Robert et al. (2009); Dubey et al. (2017, 2019)	1. Our partners are trustworthy (ST1) 2. We have no reason to doubt each other's competence and preparation for task (ST2) 3. While working together on specific task, I believe I can rely on them not to cause

			trouble by careless work (ST3)
Collaboration (CO)	Reflective	Hemingway and Gunawan (2018)	1.We routinely share our resources (i.e., information, expertise and infrastructure) among our partners (CO1) 2. We work closely to design and implement our operations in response to disasters (CO2) 3. We share our risks and benefits (CO3)
Supply Chain Resilience (SCR)	Reflective	Altay et al. (2018)	1.Our organization can easily restore material flow (SCR1) 2.Our organization would not take long to recover normal operating performance (SCR2) 3.The supply chain would quickly recover to its original state (SCR3) 4. Our organization can quickly deal with disruptions (SCR4)
Interdependency (I)	Reflective	Moshtari (2016)	1.It would be costly for our organization to lose its collaboration with the partner (I1) 2. This partner would find it costly to lose the collaboration with our organization (I2)
Temporal Orientation (TO)	Reflective	Moshtari (2016)	1.Long-term goals in their relationship (TO1) 2.Partners expect to work together for a long time (TO2) 3.Participating organizations concentrate their attention on issues that will affect targets beyond the next (TO3)

Table C: Profiles of the Respondents

Organizations main service	*Frequency*	*Percentage*
Health	60	23.44
Logistics	78	30.47
Food security	56	21.88
Water, sanitation and hygiene	41	16.02
Camp coordination	21	8.20
Nationality	Frequency	Percentage

Asia		
China	27	10.55
DPR Korea	3	1.17
India	22	8.59
Indonesia	3	1.17
Japan	18	7.03
Thailand	3	1.17
Europe		
Belgium	6	2.34
Denmark	4	1.56
France	19	7.42
Finland	7	2.73
Ireland	5	1.95
Netherlands	13	5.08
United Kingdom	11	4.30
Africa		
Cameroon	17	6.64
Egypt	5	1.95
Niger	4	1.56
Nigeria	4	1.56
Somalia	2	0.78
South Africa	11	4.30
North America		
Canada	17	6.64
United States	52	20.31
Mexico	3	1.17
South America		
Argentina	6	2.34
Brazil	19	7.42
Chile	8	3.13
Peru	11	4.30