

# **The Implications of Complexity for Humanitarian Logistics: A Complex Adaptive Systems Perspective**

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## **Abstract**

In this study we argue that recognising humanitarian logistics (HL) as a complex system is a key step in developing supply chain design and management strategies that meet the needs of stakeholders. This study draws on complex adaptive systems theory to examine the characteristics and implications of complexity for HL. Through case-study research of humanitarian responses in Haiti and Pakistan, characteristics of complexity across organisational boundaries are identified. We find that the complexity of the context impacts the outcome of the humanitarian response and conclude that HL must not only react to its environment, it must also create its environment. As HL must work within significantly differing environments to create solutions, the standardised approaches used to manage supply chains are less desirable. While this paper focuses on HL, wider applicability to other complex logistics operations is also discussed, informing the design and management of contextually specific supply chains.

**Keywords:** Humanitarian logistics, Complex adaptive system (CAS), Case study, Supply Chain Management

## 1. Introduction

The frequency and intensity of large-scale and catastrophic disasters, natural or human-made, continues to increase (Day 2014). It has been reported that more than 200 million people are affected by natural disasters each year (Yao et al. 2018) and their survival often relies on the humanitarian assistance provided by private, military, government, and/or national and international non-governmental organisations (NGOs) (Kovács and Spens 2009; Tatham and Houghton 2011; Kovács et al. 2012; Pérouse de Montclos 2012; Chapman and Mitchell 2018).

Humanitarian assistance is provided through humanitarian logistics (HL), a system concerned with *‘planning, implementing and controlling the effective, cost-efficient flow and storage of goods and materials as well as related information, from the point of origin to the point of consumption for the purpose of meeting the end beneficiary’s requirements’* (Thomas and Mizushima 2005, p. 60). The annual expenditure of humanitarian assistance is estimated at more than US\$25 billion (Tatham and Pettit 2010), with HL activities approximated to account for as much as 60-80% of the total cost of humanitarian operations (Blecken 2010). Balancing the moral imperative that drives HL with the economic imperative for ensuring value for money presents challenges for humanitarian logisticians (Beamon and Balcik 2008; Gonçalves and Castañeda 2018; Naor et al. 2018; Cachon et al. 2020). In short, failure to provide sufficient supply in a timely manner has the potential to cause serious losses or even death (Thomas 2004; Tatham et al. 2009; Day et al. 2012; Turkeš et al. 2017; Chapman and Mitchell 2018).

Academic and managerial interest in HL was piqued after the catastrophic HL failures of the 2004 tsunami in South East Asia, with operational concerns such as custom clearance and the congestion of ports and airports being of particular interest (Kovács and Spens 2011). It has been suggested that HL presents a ‘wicked’ problem (Tatham and Houghton 2011). The sheer number of stakeholders (each with their wildly differing views and objectives) leads to increased complexity and performance issues (Hilhorst 2002; Vaillancourt 2016), in addition

to the ‘customers’ within the supply chain (SC) including both beneficiaries of aid and the donors that provide it (Oloruntoba and Gray 2009; Charles et al. 2010; Schiffing and Piecyk 2014). Furthermore, HL must operate under extreme time pressure (Dubey et al. 2017), often in environments that have neither a functioning logistics system nor adequate administrative or governmental structures (Pettit and Beresford 2009; Day et al. 2012). While there have been some efforts towards standardisation in HL, each response is unique and depends on local needs assessment and significant adaptations beyond the initial emergency response phase (Kovács and Spens 2009; Richey 2009; Kunz et al. 2014).

The HL context poses distinct challenges for the logistics function when compared with the demand-driven, steady-state SCs found in commercial industries where the required inputs to achieve the desired results are generally known (Kovács and Spens 2007; Olaogbebikan and Oloruntoba 2017; Besiou and Van Wassenhove 2020). Compared to the demand-driven, steady-state commercial industries, HL operates in an exceedingly uncertain and dynamic environment that is far beyond the control of any individual manager or organisation (Van Wassenhove 2006; Day et al. 2012). However, due to their humanitarian mandate, humanitarian organisations will not withdraw from such an environment, which necessitates agile and resilient SCs (Stewart and Ivanov 2019). Given this challenging operational context, many of the current frameworks we use to manage SCs have proven inadequate in the disaster response context (Balcik et al. 2010). The field of HL is therefore considered to be a highly dynamic, complex system (Gonçalves 2008). Research illustrates how managing HL efforts cannot be approached in the same manner as for unidirectional, linear SCs, but should instead be examined as a dynamic system (Day 2014).

By examining humanitarian relief efforts in Haiti and Pakistan, we focus on the complexity of the context and how the HL response adapts to complexity in order to provide timely and sufficient resources to where they are needed. To do this, we adopt the theoretical

lens of Complex Adaptive Systems (CAS). In the operations management literature, supply networks have been characterised as CAS (Choi et al. 2001; Pathak et al. 2007). Similarly, HL can also be viewed from the CAS perspective (Day 2014). It is characterised as complex and dynamic given that the agents generate nonlinear interactions over time, resulting in a potential emerging system behaviour, e.g. supply network resilience (Day 2014). We took a similar view and consider HL as a CAS. By utilising CAS theory we are able to develop a detailed analysis of the key tenets of complexity from which we provide theoretical and practical insights for HL.

HL has been recognised as an important research area by numerous scholars because of the considerable financial, as well as moral implications of HL performance (Jabbour et al. 2017; Banomyong et al. 2019; Anaya-Arenas et al. 2014). In parallel with its recognised importance is the acknowledgement that HL operations are complex (Hilhorst 2002; Vaillancourt 2016), yet much of this research ignores the complicating factors of HL (Day et al. 2012) and research examining the implications of complexity for HL is currently underdeveloped. Specifically, the characteristics of complexity across organisational boundaries and the ways in which HL responses interact with complexity are not sufficiently explored. By utilising the theoretical lens of CAS we are able to shed light on how and why humanitarian response efforts can yield vastly differing outcomes and offer recommendations as to how these differences can be overcome.

Our study addresses the following research questions:

*RQ1. What are the main characteristics of complexity in humanitarian logistics?*

*RQ2. How does the humanitarian logistics response adapt to complexity?*

The paper is structured as follows: section 2 examines the operating environment of HL explains our rationale for using CAS and details the application of CAS to HL. In the subsequent

research design section, the data collection and data analysis are detailed. Section 4 presents the case studies and section 5 the cross-case analysis, structured by the three foci of CAS. By drawing on our findings, we address our research questions in section 6, before we conclude the paper by reflecting on key theoretical and managerial insights as well as discussing limitations and future research directions in section 7.

## **2. Literature review**

### ***2.1 Understanding the complex operating environment of humanitarian logistics***

The challenges of HL have been explored in great depth in the extant literature in recent years (Behl and Dutta 2019; Gupta et al. 2019) and a common theme is the impact that the unique and complex operating environment has on HL operations (Turkeš et al. 2017; Gunasekaran et al. 2018). As this paper focuses on the main characteristics of complexity in HL, this section reviews prior research on complexity within HL.

Firstly, the operating environment is dynamic, whereby temporary SCs must be hastily formed under conditions of extreme uncertainty (Day 2014; Gao 2019). Secondly, the number of stakeholders is significant, with military, governmental, and private organisations of various sizes and motivations typically involved (Kovács and Spens 2009; Balcik et al. 2010; Larson and Foropon 2018). Stakeholders often have differing levels of capability and their conflicting views and objectives often have a significant impact on HL performance (Hilhorst 2002; Heaslip et al. 2012; Vaillancourt 2016). Thirdly, responses have to be timely, yet they are often carried out in conflict zones with significant security threats, whilst also considering long-term recovery as well as short-term emergency aid (Gustavsson 2003; Olorunfoba and Kovács 2015).

While these characteristics alone make for an extremely challenging operating environment, HL is further complicated by the uncertainties inherent in the humanitarian relief industry. Many humanitarian organisations are facing skills and funding shortages, particularly

a lack of investment in technology and communication tools (Gustavsson 2003; Kovács and Tatham 2010; Kovács et al. 2012). Logistics is often undervalued at a strategic level, resulting in a lack of expertise in the area, which can impact on the accuracy of the information needed to develop an informed HL response (Sandwell 2011). Added to all of this is the over-reliance on donor funding, whereby donors become increasingly powerful players in the SC due to their ability to only provide financial and material support if their individual preferences and mandates are met (Hilhorst 2002; Kovács and Spens 2008). Co-ordination and collaboration between the humanitarian organisations involved is paramount if a HL operation is to succeed, and yet these activities are made more difficult as all of these organisations differ vastly in their size and approach (Kovács and Spens 2009; Moshtari 2016), and knowledge sharing is hampered by the chaotic and uncertain environment of HL (Pateman et al. 2013; Heaslip and Barber 2014; Altay and Pal 2014; Gao 2019).

While there is a growing body of research in HL, scholars are critical of HL research that ignores complicating factors or distorts the situations faced in practice (Day et al. 2012). HL researchers are therefore encouraged to guard against over-simplifying inherently complex and ill-structured situations (Apte 2009). Inspired by this, Day (2014) concluded that the differences in the flows of finance, information, and resources are so great that HL efforts cannot be managed in the same manner as unidirectional, linear SCs, but should instead be examined as dynamic and complex systems to better understand HL and to '*generate more reliable disaster relief performance*' (Day 2014, p. 1985). Other scholars have characterised HL as a highly complex (Seybolt 2009; L'Hermitte et al. 2015; Stauffer et al. 2018) or 'wicked' problem (Tatham and Houghton 2011). However, definitions of the actors, processes and contexts that comprise the dynamic and complex system of HL are under-developed in the literature. Therefore, this paper aims to explore not only the characteristics of complexity experienced in this scenario, but also the impact these characteristics have on HL responses. We present

findings from case-study research on complexity in HL and enhance our understanding of the divergent outcomes of different humanitarian responses.

## ***2.2 Theoretical lens: Complex Adaptive Systems***

The term CAS emerged from complexity theory (Prigogine and Stengers 1984; Lewin 1993; Kauffman 1995), which focuses on the emergence of order in dynamic and non-linear systems that operate at the edge of chaos (Schneider and Somers 2006). A CAS is a type of system that functions without any central control and lacks a permanent, fixed structure, yet is nonetheless distinguishable from its surroundings, with examples including ecosystems and cities (Holland 1995). Within a CAS, developing an understanding of its constituent ‘parts’ does not necessarily convey an understanding of the whole system’s behaviour (Brownlee 2007). The ‘parts’ of a CAS are independent agents. In operations management terms, an agent may be an individual or an organisation, yet in scientific terms an agent may be a molecule or a species. A CAS is considered *complex*, as it is diverse, and *adaptive* in that the system has the capacity to alter and change based on learning from experience (Begun et al. 2003).

Studies that have viewed HL through a CAS lens have examined the applicability of commercial SC thinking to humanitarian SC relationships (McLachlin and Larson 2011), coordination in HL (Krejci 2015), and how HL resilience can be enhanced (Day 2014). Other studies also refer to HL as a CAS, however the definition of CAS is not always made explicit, or the notion of HL as a CAS is taken as read and is not elaborated upon (e.g. de Faria Cordeiro et al. 2015; Shafiee and Berglund 2016; Handayani et al. 2017). Prior research suggests that this theoretical approach could add to the body of knowledge in HL (Gupta et al. 2019). To better understand the complex interplay inherent in supply networks, researchers suggest a CAS perspective (Langdon and Sikora 2006; Pathak et al. 2007; Li et al. 2010; Schoenherr et al. 2012). Indeed, the humanitarian aid community as a whole has been described as a complex, open, adaptive system (Seybolt 2009). HL exhibits the characteristics of a CAS as the system-

level behaviour that emerges cannot be predicted by observing individual agents. It is *complex* in that it operates in a dynamic network of diverse interacting agents, and it is *adaptive* in that the system redesigns over time corresponding to internal or external stimuli. The activity of redesign is termed as self-organisation (Choi et al. 2001). In its ability to learn from its experience, a CAS evolves based not only on the dynamic interactions among its agents but also based on the interactions between the environment and the agents. As part of a humanitarian response, individual organisations can be seen as interacting adaptive agents that are united in a common purpose, i.e. providing humanitarian assistance (Kovács and Spens 2009; Tatham and Houghton 2011; Kovács et al. 2012; Pérouse de Montclos 2012). No single agent can claim to manage and control the entirety of the humanitarian effort. However, a system can support overall behaviour that is significantly more complex than the behaviour of any individual agent (Van Dyke Parunak 1997).

### ***2.3 Application of CAS to HL***

We contribute to the extant literature by offering a more fine-grained approach that adopts an analytical framework developed by Choi et al. (2001) which considers supply networks as a CAS. By utilising a framework developed specifically to consider supply networks as a CAS, Choi et al. (2001) argue that behaviours across the supply network can be interpreted in a more complete manner and therefore interventions can be developed that are more likely to deliver positive results. Both Krejci (2015) and Day (2014) refer to this framework in the context of HL and we offer an extension to this body of work by offering empirical examples.

As per Choi et al. (2001), we consider an examination of a CAS to comprise the interplay between the system and its environment, and the co-evolution of both the system and its environment. For HL the system is the network of organisations that provide the humanitarian response and the environment is the context in which the humanitarian response

is provided (e.g. geographical location, political situation, accessibility) (Balcik et al. 2010). In considering supply networks as a CAS, Choi et al. (2001) suggest three foci; *internal mechanisms*, *environment* and *co-evolution*. The dynamics of these three foci provide the framework for our study and allow us to examine and develop suggestions as to how the design and management of HL can be improved. In contextualising each of these foci to HL, we consider *internal mechanisms* as concerned with the agents (e.g. individuals and organisations) that comprise the humanitarian relief effort. We are concerned with the connectivity and the ability to self-organise in and between the agents and how information and resources flow. Here, we also examine the norms, values, beliefs and assumptions that are shared among agents. The *environment* exists external to the CAS; for HL this focus would concern contextual, cultural, geographical, political and financial factors that could influence change within the CAS. These environmental factors may be dynamic, and hence force the CAS to exploit existing knowledge and explore new knowledge as part of the change (Choi et al. 2001). The third focus, *co-evolution*, concerns the CAS both reacting to and creating its environment. Feedback between the system and its environment forces change within the CAS and also within the environment. Co-evolution may instigate a change from equilibrium to disequilibrium between a system and its environment. For instance, political instability in the geographic location where HL is required can lead to unpredictable changes that influence the behaviour within the CAS; an example of this would be the local government being overthrown, resulting in changes to the balance of power, thereby forcing some HL actors to withdraw from the region. Change is often non-linear in a CAS. Non-linearity implies that there is an inconsistent relationship between the cause and effect of CAS events, such that cause and effect can be difficult to predict, and this relationship may not be repeated, or that extreme events may yield disproportionately negative or positive results (Wycisk et al. 2008). For example, a large change in input (e.g. additional funds as donations) does not necessarily lead to large changes in

outcome (e.g. additional funds may not be used to their greatest effect, or additional supplies purchased with the funds may not reach the intended recipients). Conversely, a small change in input may lead to a significant change in output (either positive or negative). A CAS can therefore be hypersensitive to changes in its environment (Choi et al. 2001). A summary of these three foci are included as Table 1.

Table 1. The three foci of complex adaptive systems in humanitarian logistics.

<b>CAS Focus</b>	<b>Humanitarian Logistics context</b>
Internal mechanisms	Concerned with the agents that comprise the CAS
	Agents are individuals and organisations that provide the humanitarian relief effort. For example, private, military, governmental and non-governmental organisations, donors and beneficiaries
	Examines connectivity and ability to self-organise within and across these individuals and organisations
	Develops understanding of norms, values, beliefs and assumptions that are shared among individuals and organisations
Environment	Concerned with factors outside of the boundary of the CAS
	For HL the environment may comprise contextual, cultural, geographical, political and financial influences
	Environmental factors may be dynamic in HL, and force the CAS to adapt quickly to changing influences
Co-evolution	Concerned with the CAS both reacting to and creating its environment
	Concerned with changes in the equilibrium state between a CAS and its environment
	For HL, political instability, for example, in the geographic location where HL is required can lead to unpredictable changes that influence the behaviour within the CAS
	Examines non-linearity as regards how a large change in input does not necessarily result in a significant change in output

These three foci are not independent of each other, meaning that, for example, non-linearity (co-evolution focus) is affected by the CAS agents' adaptation efforts but can also introduce new patterns of self-organisation and emergence (internal mechanism focus) (McCarthy et al. 2006). This may imply that different agents at different levels of a CAS share the same concerns, such as increasing delivery speed and reducing costs (Surana et al. 2005;

Wycisk et al. 2008). As such, each individual agent aims to address their own concerns but may end up instigating the emergence of similar collective patterns at the wider system level (Pathak et al. 2007).

In summary, HL can be defined as a CAS as it emerges over time into a coherent form and adapts and organises itself without any singular entity deliberately managing or controlling it (Holland 1995). Hence, employing the established theoretical lens of a CAS is regarded as an important step towards understanding how the highly-complex operations of HL can be designed and managed, and will enable the development of theoretical and practical insights into how collective behaviours in delivering humanitarian responses can be coordinated (Surana et al. 2005; Moshtari 2016). We do this by examining the humanitarian responses to the Haitian earthquake and Pakistan floods (both of 2010) and outline our research design below.

### **3. Research design**

This study utilises a case study research design. Case studies are defined as ‘*empirical enquiry that investigate a contemporary phenomenon within its real life context*’ (Yin 2014, p. 14) and are characterised by the collection of contextually rich data. This makes them a suitable approach for the study of complex social phenomena in which a variety of variables, some of them unknown to the researchers, shape particular responses or outcomes in a network of interactions (Stake 2000; Flyvbjerg 2013). Case studies are commonly used to explore, and make sense of, complexity (Flyvbjerg 2013; Yin 2014; Kreye et al. 2015; Campus et al. 2019), with qualitative methods being noted as particularly appropriate for ‘*allowing researchers to deal with complexity, context and persona and their multitude of factors, relationships and fuzzy phenomena*’ (Cassell and Gummesson 2006, p.167).

#### **3.1 Data collection**

Semi-structured interviews and document analysis provided the multiple data sources necessary

*'to seek convergence and corroboration through the use of different data sources and methods'* (Bowen 2009, p. 28). This *'combination of methodologies in the study of the same phenomenon'* (Denzin 1970, p. 291) achieves triangulation, thus reducing any potential biases and substantiating findings across datasets (Voss et al. 2002; Bowen 2009). Publicly available documents for each of the organisations that participated in the interviews were collected; these included mission reports, annual reports, operational updates, and intra-, as well as inter-organisational reviews. In total, 18 interviews were conducted. Respondents all worked within humanitarian NGOs, many with considerable experience at the time of the interview (See Table 2 for details).

Table 2. Length of service and job title of interviewees (adapted from Makepeace et al. 2017).

<b>Interviewee</b>	<b>Length of service within the sector (years)</b>	<b>Length of service within the organisation (years)</b>	<b>Job Title</b>
H1	8	5	Programmes Coordinator
H2	5	3	Head of Operations
H3	13	8	Head of Logistics and Supply
H4	5	5	Chief Executive Officer
H5	4	1	Logistics and Procurement Coordinator
H6	11	7	Director of Programmes
H7	9	6	Logistics Advisor
H8	12	9	Deputy Director Procurement and Logistics
H9	8	6	Operations Manager
H10	16	4	Country Supply Officer
P1	9	7	Medical Supply Officer
P2	4	2	Mission Support
P3	17	10	Operations Director
P4	4	1	Logistics and Procurement Coordinator
P5	9	6	Logistics Advisor
P6	6	4	Mission Coordinator
P7	13	8	Head of Logistics and Supply
P8	12	9	Deputy Director Procurement and Logistics
Total	165	101	

Interviewees were identified using a combination of theoretical sampling and snowball sampling; some interviewees were contacted directly based on their role and the organisations they worked for, while others were identified via referrals (Saunders et al. 2006; Bryman 2012). As most respondents were actively conducting humanitarian work around the world, most interviews were conducted by phone or online via Voice Over IP. To protect their anonymity, participants are only identified by an alphanumeric code, where ‘H’ stands for participation in the Haiti case study and ‘P’ for Pakistan. A number is assigned at random to each interviewee.

Table 3. Organisational characteristics.

<b>Organisation</b>	<b>Type</b>	<b>Haiti</b>	<b>Pakistan</b>	<b>Interviewees</b>	<b>Base</b>	<b>Area Served</b>
A	Dunantist	1		H9	Single Country	Global
B	Dunantist	1	1	H3, P7	Global	Global
C	Dunantist	1	1	H7, P5	Global	Global
D	Dunantist		1	P3	Global	Global
E	Dunantist		2	P1, P6	Global	Global
F	Religious	1		H1	Single Country	Single Country
G	Religious	1		H2	Single Country	Global
H	UN	1		H10	Global	Global
I	UN	1	1	H5, P2	Global	Global
J	Wilsonian	1		H6	Global	Global
K	Wilsonian	1		H4	Single Country	Global
L	Wilsonian	1	1	H8, P8	Single Country	Global
M	Wilsonian		1	P4	Single Country	Global

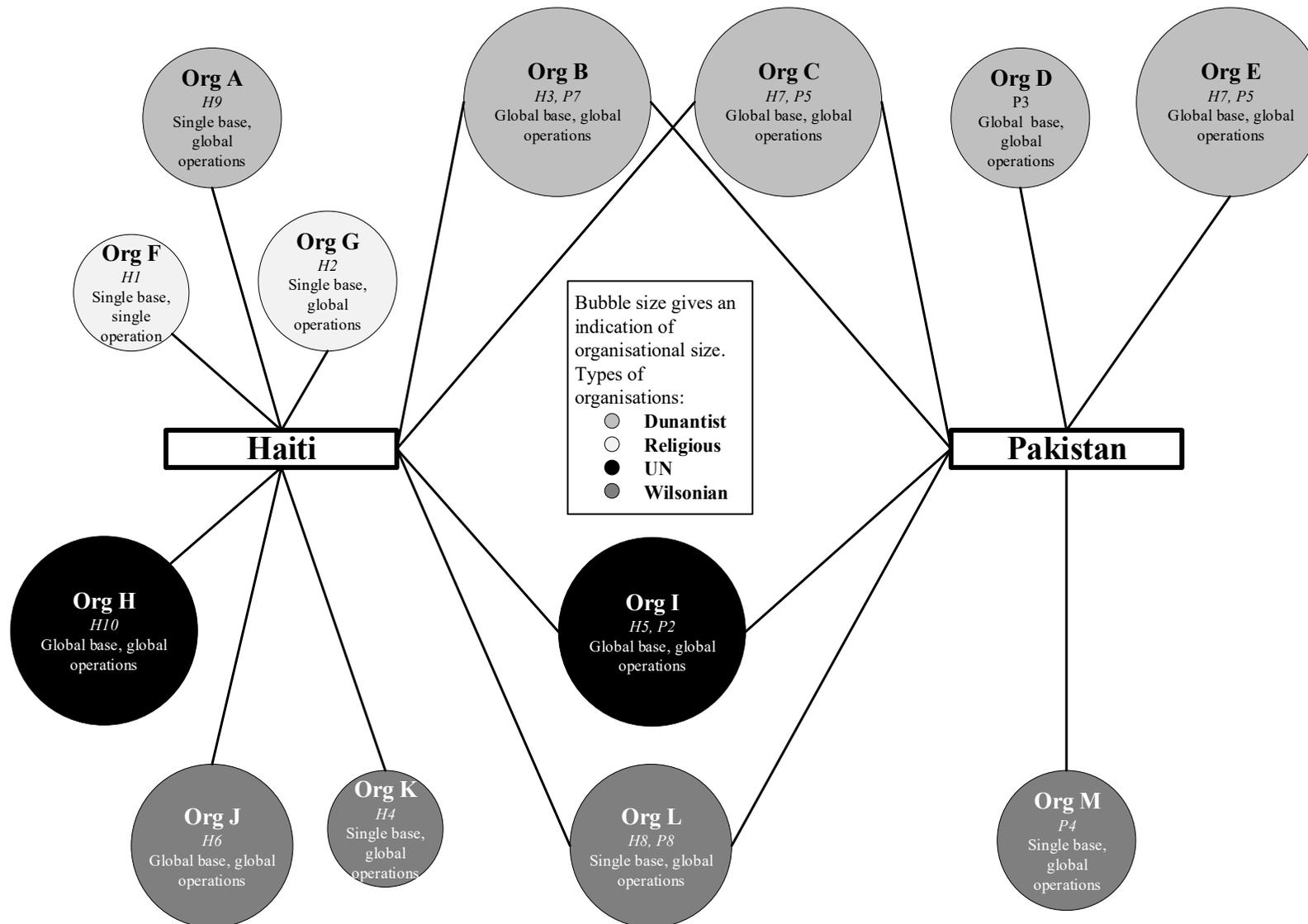
Four different types of non-profit organisations were included in this sample; UN agencies, religious organisations conducting humanitarian operations according to faith-based objectives, Dunantist and Wilsonian organisations. Following the classification by Stoddard

(2003), Dunantist organisations are independent of, or even oppositional to, government and are advocacy-focussed; in comparison, Wilsonian organisations are more dependent and cooperative with government and are focussed on service delivery. Table 3 provides a summary of the organisations that participated in the study.

As previous research has highlighted, humanitarian efforts do not end instantaneously after the emergency response, but often merge into long-term efforts of recovery and rebuilding (Day et al. 2012; Oloruntoba and Kovács 2015) with these interconnected phases being a recognised source of complexity (McEntire 2004). Thus, interviews were conducted in 2014 and 2015 to allow for longer-term reflections on the humanitarian responses, including considerations of outcomes. Asking respondents to recall events from several years ago allowed the authors to focus on the immediate disaster response, whilst also acknowledging the potential wider impacts of complexity.

While the sample size may be considered relatively limited when compared with large scale logistics studies in different contexts, the poor availability of data in HL is widely acknowledged (Kovács and Spens 2007; Natarajathinam et al. 2009; Kunz and Reiner 2012; Pedraza-Martinez et al. 2013; Kovács and Moshtari 2019). Figure 1 provides an overview of the boundaries of the two case studies. It highlights the different types of organisations and visualises their differences in size. Care was taken in the sampling process to include organisations of varying sizes, however in practice fewer smaller organisations responded to the floods in Pakistan. Organisations B, C, I, and L were represented in both case studies. All four of these organisations are of a considerable size and operate globally, with all except organisation L also having a global base.

Figure 1. Overview of case studies and interview participants.



### **3.2 Data analysis**

As interviewees were asked to recall events that had occurred some years ago, comparisons across interviewee responses and with the secondary data were made after every interview to establish any inconsistencies (Smith 2001). As inconsistencies were not identified across the recollection of events, the associated challenges of analysing multiple versions of the ‘facts’ (whether misremembered, misinformed, withheld or untrue) did not need to be addressed (Polishuk 1998). The interviews were recorded and their transcripts analysed in NVivo using, initially, an a priori coding process (Miles et al. 2014).

In analysing our primary and secondary data, we drew on the approach adopted by Bhakoo and Choi (2013). A priori first level codes were derived from the three interdependent foci of the CAS framework utilised (internal mechanisms, environment, and co-evolution) (Choi et al. 2001) and drew on contextual information as presented in Table 1. As per Table 1, operational definitions of each code were developed, thus providing a clear guideline regarding the contents to be coded. For example, when coding against ‘internal mechanisms’, interview comments and secondary data referring to connectivity between agents and/or the norms, values, beliefs and assumptions shared between the agents were of interest. For ‘environment’, the coding process was concerned with identifying primary and secondary data about factors outside of the boundary of the CAS, which were expected to be based around contextual, cultural, geographical, political and financial influences. Finally, for ‘co-evolution’, coding focused on collecting interview responses and secondary data detailing changes in the equilibrium state between the CAS and its environment and examples of non-linearity. Each interview was coded on at least two separate occasions as recommended by Miles et al. (2014), revisiting the initial coding after several days to ensure internal consistency. The data analysis process continued until a point of saturation was reached (Robson 2011).

Validity and reliability are key considerations in presenting the findings of the case-

study research (Creswell 2014). We conducted a cross-case analysis, which allows for some replication in findings (Stuart et al. 2002). Internal validity (Lincoln and Guba 1986) was ensured by triangulating data from interviews and document analysis (Bowen 2009). With several sources of information available for each organisation in the sample, findings did not depend on the interpretations and opinions of any one respondent. Our case selection is not based on representative random samples (Eisenhardt and Graebner 2007) but rather focussed on the contextual uniqueness of the cases studied, allowing for a detailed account of the cases that can enable researchers to make an informed judgment about the possible transferability of findings (Johnson et al. 2006). Reliability or dependability (Guba and Lincoln 1994; Lincoln and Guba 1986; Lincoln et al. 2013) is achieved here by maintaining a case study database, and using electronic storage of all data and notes that clearly document the research process, thus allowing future researchers to repeat the analytical procedures (Stuart et al. 2002). A well-defined case study protocol was also employed which included an interview guide, as well as clear procedures to be followed when using it (Ellram 1996).

In the following section, we discuss each of the two humanitarian responses individually and then detail the results of our cross-case analysis, building up a rich picture of the three interdependent foci of the CAS framework as applied to HL responses.

#### **4. Case Studies**

The two case studies selected were the humanitarian responses to the January 2010 earthquake in Haiti and the July 2010 floods in Pakistan. These two natural disasters occurred in the same year, but garnered differing levels of public interest, resulting in different funding and organisational profiles in the responses, thus forming interesting and relevant divergent cases. These two disasters were the largest of 2010, and both affected significant areas of developing nations, impacting millions of inhabitants and causing economic damage amounting to billions

of dollars. Disasters several years in the past were deliberately chosen to enable respondents to reflect on the HL design and management approaches that were utilised at the time, specifically, the ways in which HL responses interact with complexity and why they can yield such differing outcomes.

#### ***4.1 Haiti***

The emergency response to the January 2010 earthquake in Haiti was seen to be particularly pertinent due to the high media attention and extensive levels of global aid, as well as the significant problems associated with HL. On the 12th of January 2010, an earthquake with a magnitude of 7.0 on the Richter scale devastated the Haitian capital Port-au-Prince and surrounding areas, with a series of strong aftershocks adding to the destruction (Margesson and Taft-Morales 2010). The Em-Dat database (2015) lists the number of total deaths as 222,570 with 3,700,000 people affected and a total economic damage of US \$30 billion, thus making it the largest natural disaster of 2010. By December 2012, US \$6.373 billion had been pledged by nations and international institutions such as the European Commission, the International Monetary Fund, and the World Bank (Office of the Special Envoy for Haiti 2013). With a GDP of US \$6.623 billion in 2010 and a GDP per capita of US \$665.63, Haiti was both a small economy and among the lowest income countries in the world (World Bank Data 2020) and already the recipient of extensive developmental humanitarian assistance (Margesson and Taft-Morales 2010).

HL was complicated by damage to the port of Port-au-Prince, which only became operational again ten days after the earthquake due to the anchoring of a floating pier (United States Southern Command 2010). The US military took over management of the only international airport and created a system for coordinating its limited capacity (Haiti Logistics Cluster 2010). The main road connection to the Dominican Republic was also damaged, but

promptly repaired by the neighbouring country (Holguín-Veras et al. 2012). The Logistics Cluster determined that the capital of the Dominican Republic, Santo Domingo, would be used as a staging area for inbound air and sea shipments before onward transportation by air, road, or sea to delivery points within Haiti (Haiti Logistics Cluster 2010). On the demand side, shelter and drinking water were priorities, particularly as water was in insufficient supply even before the earthquake. Food supplies were also urgently needed as much of the personal, commercial, and humanitarian organisation's inventories within the country had been destroyed by the disaster (Holguín-Veras et al. 2012). Efforts were made to ensure that the humanitarian response addressed needs outside of Port-au-Prince, as demand was high across large parts of the country (Inter-Agency Standing Committee 2010). The international humanitarian response was significant, with an estimated 400 international actors deployed to Haiti by the end of January 2010, with estimates of between 1,000 and 2,000 international agencies being involved in the response (Inter-Agency Standing Committee 2010). Due to the geographical proximity, a multitude of US organisations were involved, and significant media attention resulted in new actors engaging with the response, many of whom were inexperienced humanitarians (DARA 2011). The response originated from a wide range of nations including non-traditional donor countries like Brazil, Venezuela, and Cuba (Margesson and Taft-Morales 2010; DARA 2011).

#### ***4.2 Pakistan***

Pakistan had a GDP of US \$177.66 billion in 2010 and a GDP per capita of US \$987.41, both of which were significantly higher than in Haiti (World Bank Data 2020). In contrast to the Haiti case study, the emergency response to the Pakistan floods of July 2010 suffered from a lack of media attention and global aid. On 26th July 2010, heavy monsoon rains in several regions of Pakistan resulted in a major flood in the Indus River Basin, with water covering up to 20% of Pakistan's total surface area, and not receding until the autumn (Singapore Red Cross

2010; International Development Committee 2011). The Em-Dat database (2015) lists the number of total deaths as 1,985 with 13,400,000 people affected and total economic damage of US \$9.5 billion, thus affecting significantly more people than the earthquake in Haiti in the same year, but causing less deaths and economic damage. It is estimated that more than 12 million people were displaced and 1.7 million homes were either damaged or completely destroyed, which demanded a humanitarian response on an unprecedented scale, putting strain upon the resources of both humanitarian aid organisations and donor countries that were already stretched by the Haiti response (International Development Committee 2011). The scale of the damage resulted in the largest appeal in the history of the UN, as the Government of Pakistan requested US \$459 million for a three-month period and a funding requirement of US \$1.9 billion was identified for a one-year period (International Development Committee 2011).

Given the scale of the emergency and the insufficient local capacity and experience in disaster management, the response suffered from limitations in terms of aid delivery (Polastro et al. 2011). As a result of the Haiti earthquake, stocks of nationally-produced relief items such as tents were depleted and there was no production capacity to match demand (Polastro et al. 2011). NATO offered assets including an air bridge from Europe to Islamabad to facilitate fast and cost-efficient movement of goods, but while use of the air bridge by humanitarian organisations was strongly advocated by the UK, US, and Pakistan governments, many viewed this use of military assets as a breach of humanitarian principles (International Development Committee 2011; Madiwale and Virk 2011). The impact of the flood was very different in each province due to the changing nature of the disaster, the different levels of preparedness, and the access to individual and common resources (Polastro et al. 2011). Demand was greatest for improved water and sanitation, with food, medicines and healthcare increasing in importance 6 months after the disaster as households reported unmet needs (Kirsch et al. 2013). The government of Pakistan distributed cash-based assistance under the Watan scheme, which

provided much needed local aid, but was also criticised for being overly bureaucratic and inflexible (International Development Committee 2011). Across the response, there was extensive usage of military assets for transport; Pakistan's armed forces spent nearly a quarter of their annual budget on the flood response, but in areas such as Balochistan, which was in armed conflict with the Pakistan government at the time, using the army for humanitarian purposes was not possible (Madiwale and Virk 2011). The army was praised for its swift initial response and its effort in restoring transport infrastructure and enabling road access (International Development Committee 2011). Significant funding and donations in kind were raised outside of the UN appeal, often originating from emerging and non-traditional donors such as Turkey and Saudi Arabia, the Pakistani Diaspora, and the private sector (Polastro et al. 2011).

## **5. Cross-Case Analysis**

The previous sections have provided an overview of the complexity of the operational environment to the two humanitarian responses. Issues highlighted are in concordance with the extant literature, for example the uncertainties of funding in humanitarian organisations. In this section, we conduct a cross-case analysis of the effects of that complexity across organisational boundaries, and the ways in which HL responses interact with them. We conduct the cross-case analysis from the perspective of HL as a CAS by using Choi *et al.*'s (2001) framework of three CAS interdependent foci; internal mechanisms, environment, and co-evolution as outlined in Table 1. We consider each of these foci in turn, offer examples from the field, and discuss the implications for HL across the two case studies in accordance with the research questions. A summary of the findings is presented in Table 4 outlining common themes that emerged in both cases and themes that were distinct to each case.

Table 4. Summary of findings.

<b>CAS Focus</b>	<b>Common Themes</b>	<b>Haiti</b>	<b>Pakistan</b>
Internal Mechanisms	<p>Multiple agents with limited connectivity</p> <p>Unwillingness or inability to self-organise</p> <p>Concerns about maintaining neutrality</p>	<p>Focus on donor priorities rather than beneficiary involvement</p> <p>Highly competitive environment with many NGOs</p>	<p>Limited beneficiary involvement due to security concerns</p> <p>Competition, but some collaboration between NGOs</p>
Environment	<p>High degree of uncertainty on the ground</p> <p>Out-dated information and challenges in evidencing cause and effect</p>	<p>High dependence on global political agendas and media attention</p> <p>Uncooperative national government</p> <p>Evasion of local governance structures</p> <p>Access issues to the country</p>	<p>High reliance on government funding politicised the response</p> <p>Influence of tribal structures</p> <p>High reliance on local knowledge</p> <p>Government constraining access to certain regions</p>
Co-Evolution	<p>Struggle to adapt to constant changes</p> <p>Limited understanding of systemic issues</p> <p>Reluctance to work together to improve the system</p>	<p>Many inexperienced newcomers</p> <p>Overall response did not deliver on outcomes</p> <p>Weak government and humanitarian structures</p>	<p>Global competition of NGOs negatively impacts cooperation</p> <p>Efforts by national government and international bodies to structure the relief efforts</p>

## ***5.1 Internal Mechanisms***

To function as a CAS, agents connect with other agents in the system and make decisions based on imperfect information (Schein 1994; Choi et al. 2001). Our data indicates that there are similar characteristics in both cases regarding agents' attributes and their interaction. Beneficiaries, donors, the military, and local and international NGOs were the key actors involved in both humanitarian responses. These agents form a complex network.

To deliver humanitarian assistance as part of a CAS, agents must work together. We found, however, that in both case studies, there was limited connectivity among agents and that a culture of sharing was less evident. Agents appeared to be working independently and in competition, thus reducing the opportunities for shared learning that is necessary for a coherent and structured humanitarian response. The lack of shared learning was linked back to the lack of experience and expertise of some agents:

‘The performance of the cluster system was mixed [...] only those agencies with operational experience and a proven record in the sector should be involved in cluster meetings and that information should be shared with others in a less resource intensive manner.’ (P8)

Agents from diverse sectors and with a variety of motivations can be connected in the context of HL and enter into competition for resources, services, donations, and beneficiaries. In Pakistan, there was intense competition between agents on both the donor and the beneficiary side of the humanitarian response (P2, P4, P6). The Haiti response had media attention and sufficient funding, but had agents scrambling for their share of the overall monetary flow (H1, H2, H6, H7, H8). Agents readily acknowledged the competitive culture, which was perceived by some as a threat to the overall relief operation:

‘Unfortunately, you have to say that it is quite a big competition [...] the real problem is that people do not want those efficiencies. The brand of an organization has to be seen

first, particularly in sexy disasters. Every organisation wants to be seen as leading the way.’ (H6)

The impact of the culture of competition and lack of connectivity was an unwillingness, or inability, to self-organise as a HL relief effort. The outcome of agents’ self-organisation was the duplication of efforts, with interviewees acknowledging that ‘*there is very little cooperation [...] we need to stop replication and draw on each other’s strengths*’ (P6).

In the Haiti response, beneficiary involvement was seen as the most crucial aspect of stakeholder management owing to the very complex situation in a country that was already deeply impoverished before the earthquake (H1, H2, H4, H6, H9), but respondents acknowledged that donor demands were frequently prioritised (H1, H6, H7). In the Pakistan response, beneficiary involvement was limited because of the security concerns inherent to the response, despite organisations realising that having closer interactions with beneficiaries was essential for the sustainability and impact of their work (P3, P6, P8). Limited interaction with beneficiaries carried the risk of jeopardising humanitarian principles, as safe areas and groups of people are prioritised, rather than those in most need of assistance (P8), which in turn can create further security concerns (P5). This highlights the complexity of interactions with beneficiaries as key agents in the CAS.

Within the definition of internal mechanisms, the dimensionality of a CAS is defined as the degrees of freedom that the individual agent is able to act autonomously without relying on other agents (Dooley and Van de Ven 1999). We found that there were three main factors that reduce the agents’ degrees of freedom in the context of HL. First, maintaining neutrality appeared to reduce dimensionality; we found that maintaining neutrality in these highly political disaster responses presented a major challenge (H1, H6, H7, P5, P6, P7, P8). While some organisations were very open in their approach to lobbying, describing it as essential to ‘*work with the governments and the ones that decide where the money goes*’ (H1), others were

very sceptical of any political engagement, insisting that their neutrality was their very *raison d'être* (H2, H7). While most organisations firmly insist on their neutrality, even if they closely cooperate with the military for practical reasons (P4, P8), they also acknowledge the intense political nature of their work:

‘There’s a lot that’s fluff, policy and other things and politics in these organisations but by and large we are probably a more political organisation than anything else.’ (P7)

‘Neutrality and all that rubbish... those are all fine principles, but it is a very political context and everybody who does not admit that is simply telling lies.’ (H6)

Second, accountability to donors also limits dimensionality. The requirement for high visibility in order to attract donations made the response a matter of prestige for HL organisations, both established ones and newcomers to the humanitarian industry (H1, H7). This would indicate that agents’ actions for attracting and maintaining donations might be prioritised over the concerns of the beneficiaries. Donor involvement was seen as a substantial challenge, but also of high importance as accountability to donors shapes and guides performance in HL (H2, H3, H6, P1, P4, P7). Donors gave guidelines for an organisation’s spending and demand accountability (H6), or earmarked funding for particular activities (P3). There was a drive towards the efficient use of resources, as donors demanded evidence of how their money was being used, thus increasing financial prudence and having a significant impact on how resources are deployed (H1, H5, H9). Respondents also pointed out that donor demands were not always reasonable and that they struggled to comply with them whilst trying to focus on beneficiary needs (H3, H6, P5, P7). Haiti was seen as an anomaly among respondents as the extensive media engagement resulted in a significant influx of donations; this was in sharp contrast to other disaster responses in the same year that struggled for funding (H6, H8, H9):

‘Earthquake Haiti, everybody wants to donate everything, but other areas don’t receive quite as much media attention, it’s a lot more difficult.’ (H5)

Delays to the disbursement of requested funds in the Pakistan case study (P8) led to it being ‘*a struggle to keep all of that funded*’ (P3) continuously, particularly as media attention tends to move away from longer-term disasters such as floods over time (P4, P7). The resources of many agents were already stretched due to the Haiti earthquake earlier in the year and the willingness and ability of donors to contribute to yet another major humanitarian response was questionable at best (P8). Much of the received funding was ear-marked for Haiti and therefore could not be used in Pakistan (P1, P4, P7, P8). Therefore, needs in Pakistan remained unmet (P5, P7), while in Haiti money might have been spent carelessly by some agents (H1).

Third, in both responses, military involvement was a significant concern, which can further limit dimensionality (H5, H7, H9, H10, P1, P2, P4, P7, P8). The Pakistan army had previously been employed in some of the affected regions in a defensive capacity; this resulted in tensions with the affected populations, as well as reports of humanitarian organisations being denied access to certain affected areas (P2, P5, P8). However, the significant contribution of the national military forces (especially in the immediate aftermath of the floods) was also acknowledged by some who felt ‘*the Pakistan military played a pivotal role in the response across the country in rescuing the stranded population and providing the basic services*’ (P3). Similarly, international military forces were deployed despite unease about their impact on the key humanitarian principles (P1, P2, P5):

‘We strongly support key humanitarian principles of neutrality and impartiality. Using military assets for the delivery of humanitarian assistance is generally an option of last resort in conflict-affected areas because the intentions of such assistance could be misconstrued.’ (P8)

In Haiti, US Army support was accepted by the Haitian president to help coordinate the influx of goods into the single airport in the country, which was clogged up with aid deliveries and not utilising its full capacity due to inefficient air traffic control (H9). Interviewees

recognised that the involvement of the US Army enabled essential support that allowed humanitarian organisations to better coordinate their efforts, whilst also ensuring that desperately needed supplies could actually enter the country (H7, H10). Some participants, however, voiced concerns over the undue influence a foreign military power may have in shaping the fate of a sovereign nation (H5, H7).

Taken together, although the agents' degrees of freedom were limited by accountability to donors, maintaining neutrality and concerns about military involvement, they were still able to act in an autonomous fashion on the ground. This was demonstrated in the form of the simultaneous and parallel actions of agents with different skillsets and motivations. Therefore, with no one agent deliberately organising and controlling the HL activities, we see that the focus of the agents' response efforts remains at the organisational, rather than systemic level, which may have a negative impact on a unified, effective systemic response. Neither case study exhibited clear examples of connectivity, or of shared learning, between the agents that comprised the humanitarian responses.

## ***5.2 Environment***

HL operates in a particularly challenging external environment, which is dynamic as it is constantly changing. Respondents described the environment as '*volatile*' (P1) and '*an uncertain business*' (P7), which made it difficult for agents to collect real-time information. Consequently, plans and actions are based on out-dated information (H2, H3, H10). Humanitarian operations (particularly in the initial stages) were severely hampered by out-dated information on which plans and actions were based (H2, H3), for example through inaccurate numbers of inhabitants in an area resulting in insufficient amounts of goods being distributed, or incorrect maps causing transport delays (H10). In some cases, even when every effort was made to collect pertinent data centrally, by the time it was distributed and ready to be used in the field, logisticians found themselves working to situations that had changed

significantly; this resulted in inadequate needs assessment, which led to aid not meeting the needs of beneficiaries or, even worse, not even reaching some beneficiaries (H2, H3). External sources of data were often not adequate or suitable for the particular challenges of HL (H3, H10). In contrast to Pakistan, where more local knowledge was utilised, agents in Haiti failed to successfully adapt to the rapid changes as they were unable to obtain real-time information. Thus, local knowledge was considered as the best source of information and was of vital importance when coordinating and instigating the humanitarian response (P1, P2, P4). For example, local connections enabled extensive local sourcing as potential suppliers were already known to NGOs (P2, P4, P8).

There was a clear awareness that the information base needed to be improved in order to progress the development of HL, and that a variety of inputs from various views was required (H1, H4, H10). Whenever it was available, the use of actual, accurate data had a highly positive impact on logistics performance by improving purchasing and forecasting accuracy, forcing agents to prioritise data collection (H3, H9, H10, P2, P4). However, there was also a feeling that record keeping took attention away from more important tasks, with P5 stating *'the focus is on the patient, not on the records.'*

The lack of infrastructure was a major challenge for humanitarian agents in the aftermath of both disasters (H6, H7, H9, P1, P2, P6). However, agents were experienced in improvisation in order to reach beneficiaries and set up supply lines (P1, P6). In Haiti, respondents recounted their difficulties in physically getting goods, as well as personnel, into the country to an extent that astonished even experienced logisticians (H7). Once goods had entered Haiti, the situation did not improve, as the national transport infrastructure had been destroyed or had never existed to begin with (H6), an issue that was also highlighted in Pakistan (P2). In some cases, the only way to reach affected communities was with military vehicles and expertise (P8). It was then also noted that the military controlled access to assets and

monopolised some of the existing transport infrastructure, further impeding access to certain areas (P2, P8). Another characteristic of the dynamic environment that is reflected in the two cases is how the boundaries of systems temporarily shift as different agents are included or excluded (e.g. including new sourcing partners (P2, P4, P8) or excluding the military (H1, H7)). We found clear evidence of the dynamic environment of HL characterised by constantly shifting norms, rules and performance criteria.

In Haiti, global political priorities were felt to determine the amount of attention and resources the humanitarian response received, and as such they had to be managed carefully (H1, H7, H8, H10). In Pakistan, high levels of funding from international governmental donors resulted in high reliance on global political priorities and as such called humanitarian principles into question (P2, P3, P4, P8). In both responses, there was concern for the sustainability of projects initiated based on political agendas rather than on interaction with beneficiaries and recipient communities (H2, H7, H8, P2, P3). While most organisations maintained their neutrality and political independence as a core humanitarian principle, there was generally an acknowledgement that for the continuity of their humanitarian work in a particular area, agents needed to respect the politics in the context they operated in to a certain degree (P1, P2, P3, P8).

The same was true for local political impact. Humanitarian organisations often saw their role as advocates for the people they interact with and took their task of influencing and shaping political agendas seriously (P5, P6, P8). There was an acknowledgement that humanitarian work could potentially drive political change for the better, especially since politics often directly affected the populations that humanitarian organisations worked with (P5, P6). Interviewees observed that the national government of Haiti had been criticised for uncooperative behaviour, exerting its sovereignty particularly with regard to importing humanitarian supplies (H1, H3, H7, H9). On a local level in Pakistan, tribal structures played a

very important role in reaching affected populations and ensuring the safety of humanitarian organisations (P1, P2, P8). Some of the areas most affected by the floods were Federally Administered Tribal Areas and others had a very strong presence of local governance structures that were in some instances outside of the influence of the federal government of Pakistan, which controlled the access and mobility of humanitarian agents on a local level (P8). This influenced the ways in which agents could operate significantly, necessitating interactions with a multitude of different groups to gain access to affected populations (P1, P2). These examples illustrate the many factors that are outside of the boundary of the CAS but nevertheless have a significant influence on the humanitarian response.

### ***5.3 Co-Evolution***

In a developed CAS, co-evolution would gradually occur whereby a state of quasi-equilibrium becomes the norm and the system can retain some semblance of order and also be agile enough to react to environmental changes (Goldstein 1994). As a consequence of its challenging operating environment, the quasi-equilibrium of HL is consistently disrupted. In examining the internal mechanisms dimension, it was recognised that competition detracted from the shared learning that could enable better adaptation to the changing realities. While the Haiti earthquake response highlighted significant problems and emphasised the importance of managing HL relationships (H9), these lessons were not learned for the Pakistan floods (P1, P7). Simultaneous and parallel actions of independent agents according to their individual priorities resulted in inefficiencies across the CAS with duplication of efforts a problem in both Haiti (H6, H7, H8) and Pakistan (P1, P2, P6). Furthermore, excessive bureaucracy slowed down the delivery of humanitarian aid (P1, P4), for example with customs barriers:

‘Containers stuck in customs for months on end in Haiti for reasons that are unclear to us and I don’t know if that’s politics at play or just inefficiency of the systems or something else’ (H9)

While individual agents were practiced in adapting to constant changes, the overall adaptability of the CAS was a challenge. For example, interacting with changing local contacts required a high degree of cultural sensitivity that was easier to achieve for organisations who had a long-standing presence in the affected area, while others attempted, with little success, to employ standardised approaches developed in other responses (H8, P2, P5).

While both case studies started out as humanitarian responses to large-scale natural disasters, the interactions of agents and environment created different outcomes for the CAS in each case. In both Haiti and Pakistan, the environment and the network of agents were highly complex and dynamic. However, the Haiti response is recognised as particularly poor by respondents (H1, H2, H4, H6, H9). Respondents in the Haiti case study criticised a lack of engagement with competitors, highlighting an over-reliance on wider political priorities and the whims of donors rather than any actual engagement with the local communities (H1, H2, H9). The Haiti response is well-known for setting a very negative example:

‘We are mainly concerned with aid reaching the beneficiaries. Which it often doesn’t. A lot of it gets lost. Haiti is probably the prime example for how the international aid industry — it really is an industry! — can create even more of a disaster.’ (H1)

Due to cultural difficulties and access issues, stakeholder interactions in Pakistan had to be far more collaborative than in other responses (P2, P3, P4, P8), especially when planning longer-term relief efforts (P5, P8). In CAS terms, this demonstrates a somewhat higher level of connectivity between agents in Pakistan, while connectivity was limited in Haiti.

In both case studies, respondents did see opportunities for improvement across their operations ‘*if we harmonised supply chains across not just organisations, but companies as well*’ (H9). However, respondents were also critical of the initiatives to bring some organisation and coordination to the aid efforts:

‘There has been the Log Cluster [...] it was absolutely derided there. It doesn’t organise anything, it’s just another way for people to feel important about themselves.’ (H6)

A high degree of flexibility was required to enable organisations and their HLs to respond to the constantly changing local demands (H3, H10), with improvisation often being the only way to respond (H3, H8, P1, P2, P7). This demonstrates adaptation as the CAS develops. In Pakistan, attention was only drawn to HL because of significant supply problems, which several interviewees welcomed as an opportunity to highlight the necessity of investment in logistics in order to make improvements (P1, P7). In such a volatile environment where both sourcing and distribution were a challenge, interviewees acknowledged that *‘you are much more aware of logistics’* (P1). Interviewees highlighted the difficulties that every agent faced when logistics was challenged with overwhelming issues such as impeded access to affected regions (P1, P6). A similar effect was observed in Haiti:

‘The earthquake definitely changed the way that people view supply chain and really emphasised the importance of having a really strong, solid supply chain system.’ (H9)

A CAS both reacts to and creates its environment (Choi et al. 2001). However, assessing the impact of HL activities proved to be almost impossible. While organisations were able to measure input and output, the actual impact of their work remained unknown (P2, P3). There was usually a good understanding of centralised events within HL, and a general overview of the input and output of each of the humanitarian responses an organisation was involved in. However, as impact assessment needed to be conducted at a local level, a general overview only provided organisations with a fragmented and unreliable understanding of their work (P2, P3). In consequence, organisations’ understanding of their own work, and the metrics they reported to donors and other interested parties, usually did not include impact assessment, even though the desirability and even necessity of such measures was appreciated (P5, P7). Thus, it was deemed impossible to clearly evidence cause and effect within the CAS.

While Pakistan was described as a more structured environment, co-evolution failed to achieve any sort of quasi-equilibrium in Haiti. Interviewees blamed the very chaotic situation in the already deeply impoverished country, compounded by the death of many officials and local humanitarian workers (H3, H6, H8), as well as the inexperience of many of the humanitarian organisations that sprung up to respond to the earthquake (H1, H4, H5, H8). In Haiti, the capital Port-au-Prince was the focal point of the majority of the international aid shipments and grew congested very quickly (H2, H3, H7, H10). Generally, there was very little patience with the plentiful newcomers, as *'we know what we are doing and we are not here to waste our time teaching some little goody two shoes'* (H7). The lack of experience and expertise of these newcomers was accused of reducing the efficiency of the relief operation; for example, the newcomers were perceived to prolong meetings and thus detract from the actual delivery of aid (H6). Cooperation with both non-profit and commercial organisations was identified as a solution by interviewees, but there was limited reflection as to how this would work in practice (H2, H4, H9). Furthermore, the severely disrupted government and international aid structures in Haiti that resulted from the earthquake created an added layer of complexity, obscuring cause and effect relationships on a local level. This resulted in unchecked and uncoordinated agent activity that failed to achieve desirable systemic outcomes, leading to respondents remarking that *'Haiti is known as the Republic of NGOs'* (H9).

Our findings suggest that optimisation of sourcing at the local level was difficult to achieve. Respondents highlighted that their *'biggest issue is the way of sourcing and the continuity'* (P3) and many struggled to move aid deliveries into the affected areas (P1, P3, P4, P6, P8). It was noted that local sourcing was highly desirable for the ease of logistics (especially with regard to avoiding additional import costs) as well as supporting, instead of undermining, the economy of the affected area; however, interviewees pointed out the difficulties of sourcing locally in a country that had been devastated to such a scale as Pakistan in these floods (P1, P3,

P6). Similar issues were present in Haiti (H5) where *'there isn't enough food that you could buy locally, again with consistency, quality throughout the year'* (H2). Therefore, global sourcing was popular, for economies of scale, as well as the development of long-term relationships that guaranteed reliable supplies with acceptable quality. When organisations relied mainly on a small number of global suppliers (H2, H10, P4, P8), this had the potential to make global sourcing *'the easiest part, because we are working globally, we are procuring with 10-20 different suppliers'* (H10), especially for demand that was consistent across different humanitarian responses.

A lack of willpower in making sustainable changes in the political and social landscape of Haiti was observed both among humanitarian organisations and local structures (H1, H2, H6, H9, H10). Respondents observed an attitude among humanitarian organisations that was not focussed on actually improving the situation within the country, but rather often actively contradicting or evading local governance structures (H1, H9, H10):

*'You have all of these entities operating within a sovereign country that are not really listening or following the directives of the sovereign country, an —albeit questionably— democratically elected, but nonetheless a democratically elected government'* (H9)

This led one respondent to a sobering conclusion that questions the very morality and motivation of the whole humanitarian sector:

*'The NGOs really don't want to be held accountable. [...] It's bitter, but it's true; nobody has an interest in making things better. They have an interest in keeping their own jobs, that's all. And they keep their jobs if they keep the people in the country small and the suffering continues'* (H1)

This conclusion also demonstrates the difficulties of improving operations in a CAS as agents' efforts are contingent on the performance of other parts of the system.

## **6. Discussion**

This study has showcased not only the complexity of HL in both the academic literature and in practice but has also extended the current body of knowledge by applying CAS to this research area using data gathered from practitioners. We have examined the main characteristics of complexity in HL alongside how the humanitarian response reacts to this complexity. By adopting CAS as our theoretical frame, our findings show how co-evolution in HL is critical to delivering outcomes; examples show how shortcomings in co-evolution severely hampered relief efforts. We therefore offer a theoretical contribution to the field of HL by positing that a humanitarian SC must not only react to its environment, it must also create its environment. Previous work has discussed how in complex operating environments, the logistics function has to adapt and become more anticipatory to survive not merely disruption within SCs, but also macro-level volatility (Christopher 2005; Harrington et al. 2011). We go further by proposing that adaptability is insufficient for all HL contexts and, rather than reactively adapting, in some instances HL must proactively create the conditions under which humanitarian relief can be delivered. A failure to do so can negatively impact HL performance, which is, as previous work highlights, crucial for financial, as well as moral reasons (Jabbour et al. 2017; Banomyong et al. 2019; Anaya-Arenas et al. 2014).

By examining how the complexity inherent in HL impacts HL outcomes, our study demonstrates the importance of highly complex systems that are formed for a specific purpose and for a limited time frame; a clear departure from the notion of stable, long-term, linear SCs and networks. We show how HL operates as a CAS and offer practical examples of HL complexity and how these impact on the outcome of the humanitarian response. In the dynamic context of HL, and the inability of one type of response to fit the requirements of every situation, performance appears to be contingent on HL's ability not only to react to but also to create its environment. CAS as a theoretical lens furthers our understanding of how and why

humanitarian response efforts can yield vastly differing outcomes. Our discussion below addresses each of the research questions in turn and develops propositions to provide a springboard for further research.

### ***6.1 What are the main characteristics of complexity in humanitarian logistics?***

Our findings support previous work that acknowledges the complexity of HL (Hilhorst 2002; Vaillancourt 2016), and furthermore demonstrate that HL exhibits the characteristics of a CAS (Choi et al. 2001). Our particular focus is on characteristics of complexity across organisational boundaries (which we achieved by making the humanitarian response our unit of analysis) and the ways in which HL interacts with complexity. In addressing research question 1: ‘*What are the main characteristics of complexity in humanitarian logistics?*’, we find the internal mechanisms and environment perspectives from our analytical framework to be helpful. We find three important examples of characteristics of complexity emerging from our cross-case analysis that have a negative impact on the humanitarian response; i) multiple agents with limited connectivity, ii) concerns about maintaining neutrality, and iii) the high degree of environmental uncertainty. These complexity characteristics are inter-related and impact the humanitarian response. We provide a full discussion of each below.

*Multiple agents with limited connectivity* was a key facet of the internal mechanisms of the humanitarian response in both case studies and was stressed repeatedly by every respondent, with particular reference to the involvement of beneficiaries in the responses, accountability to and communication with donors, as well as interactions with the military. Rather than connecting, competition between agents featured strongly in both case studies, as working together was often seen not to be in their best interest. The dichotomy of cooperation and competition inherent to a CAS (Surana et al. 2005) was frequently addressed by interviewees, showing evidence that it creates emergent and highly dynamic realities.

Despite the lack of financial remuneration, beneficiaries are customers of HL (Oloruntoba and Gray 2009; Charles et al. 2010; Schiffing and Piecyk 2014), yet limited connectivity posed challenges to reaching consensus on a diverse range of opinions, particularly those related to local involvement and security. An inability to agree on the course of action slowed down the humanitarian response and the ability to meet the needs of beneficiaries. Satisfying the accountability requirements from donors was also hampered by limited connectivity. Accountability to donors is growing, as many parties increasingly scrutinise the humanitarian organisations' spending (Tomasini and Van Wassenhove 2009; Moore and Taylor 2011), which made respondents more aware of the need to report back to donors, yet reaching agreement on how this should be done posed challenges between agents. In the Haiti response, the relationship with the media was hampered by the limited connectivity between multiple agents. While the relationship with the media is often a strained one, it retains a vital function in soliciting donations and communicating with stakeholders (Faulkner 2001; Ritchie 2004; Van Wassenhove 2006; Lettieri et al. 2009).

A related consequence of the limited connectivity between agents appeared to be their unwillingness, or inability, to self-organise. The lack of self-organisation increased complexity for HL due to the interdependency of its constituent parts. Complexity here was characterised by the duplication of efforts across agents due to a lack of self-organisation. Duplication has previously been identified as a problem in HL and various efforts have been made to avoid it (Kovács and Spens 2009; Day 2014), with limited success as per the findings from our study.

In further examining the relationship between limited connectivity and the humanitarian response, we offer the following proposition:

*Proposition 1: Limited connectivity between agents inhibits the ability of HL to self-organise resulting in a negative impact on the speed of the humanitarian response.*

*Concerns about maintaining neutrality* were linked to complexity. There was significant concern about maintaining neutrality in both humanitarian responses, which links to the fundamental humanitarian principles (Van Wassenhove 2006). Global political priorities shaped the responses, as well as the influence of local governments. Previous studies discussed the problem of donations being tied to external agendas rather than the precise needs of the humanitarian organisations (Beamon and Balcik 2008; Jahre and Heigh 2008). In this study, differences between agents were particularly apparent as they had different philosophical backgrounds (Dunantist versus Wilsonian), making them more or less willing to tie themselves to political agendas or interact with military forces in their work or to compromise neutrality in the interest of reaching beneficiaries (Stoddard 2003). Their stance on neutrality placed restrictions on how individual agents operated, particularly at the local level, thus reducing autonomy and causing frustration. Differing views on neutrality increased complexity due to a lack of clarity and agreement about the most appropriate course of action. The impact of neutrality has significant implications for HL and hence we develop the following proposition:

*Proposition 2: The diversity of approaches to interactions with military and political entities gives agents greater autonomy to make decisions at a local level, and amplifies differences in outcomes in parts of the humanitarian response.*

*The high degree of environmental uncertainty* impacted both of the humanitarian responses due to the limited ability to formulate a workable strategy prior to arriving in the country. A common feature in the HL literature is the destruction or general lack of infrastructure (Thomas and Kopczak 2005; Altay et al. 2009; Holguín-Veras et al. 2012), which was also a key finding from our study. In both cases the extent of the destruction needed to be witnessed first-hand prior to a response being developed. Significant uncertainty arose from the continually changing situation, which inhibited the development of routines, as is typical in

emergency responses (Beamon and Balcik 2008; Chandes and Pache 2010). Our study found that humanitarian logisticians did not appear to be particularly concerned about how this uncertainty increased the complexity of their work; there was a sense of pride in being able to cope with such challenges and conduct their daily business to a reasonable standard despite all the adversities that inhibit the development of routines. Yet the constant disruption and change had a negative impact on the image of logistics, which has been linked to a dearth of professionalism (Walker 2004; Kovács et al. 2012), and an exclusion of the profession from strategic planning (Van Wassenhove 2006; Pettit and Beresford 2009), which has implications for the humanitarian response. We therefore posit that:

*Proposition 3: Developing routines as part of the humanitarian response has a significant positive impact on the HL outcome and professional standing.*

Our study presents three important characteristics of complexity in HL. We find that the individual agent's response can increase and/or add new and different complexity to the setting. This has been illustrated, for example, in our discussions on the willingness of agents to connect and self-organise, or on an agent's position regarding maintaining neutrality. We have shown how agents are not collaborating, which leads to inefficiencies including duplication and limited shared learning, and a slower response to the humanitarian disaster. In essence, the behavioural response by agents is adding to the overall complexity of HL, which leads to our fourth proposition:

*Proposition 4: In the context of HL the behavioural response by agents has the potential to increase the level of complexity.*

## **6.2 How does the humanitarian response adapt to complexity?**

In addressing research question 2: 'How does the humanitarian response adapt to complexity?' we draw on the co-evolution dimension of our theoretical framework. It is important to note

that whilst our two case studies were focused on the same outcome, providing humanitarian relief following a disaster, the Pakistan example is perceived by the respondents in our study, to have delivered a more successful response than Haiti. The perceived success of the Pakistan response is noteworthy because the scale of those affected by the disaster was greater than that of Haiti and the funds were significantly lower. Despite the different circumstances outlined above, it would therefore appear that the Pakistan humanitarian response was able to adapt to complexity to deliver outcomes in perhaps a more sustained manner than the Haiti response.

We see from the Pakistan case study that the co-evolution of internal mechanisms and the environment resulted in the relief effort being able to respond to a disaster that impacted a vast geographical area, particularly when compared with the more localised disaster in Haiti. While the response to the Haiti earthquake was much better funded than that of the Pakistan floods (and the earthquake affected fewer people across a smaller area), this did not translate into better outcomes for the country. *'Haiti is known as the Republic of NGOs'* (H9) and is still struggling to recover a decade after the earthquake, with many subsequent issues blamed on the initial disaster response. In this example, there appears to be no correlation between the level of investment and the outcome.

A key aspect of the Pakistan response that appeared to support the relief effort was that the CAS co-evolved by collaborating with actors within and outside of its boundary (e.g. local organisations and the military) to shape the humanitarian response. It was recognised that the environment of the Pakistan response was highly politicised, and this impacted on the CAS as it struggled to find an equilibrium between delivering aid and maintaining neutrality. Individual agents adapted to this challenge by defining their own priorities, shaping their environment and deciding which compromises, if any, were viable for them. In other instances, this approach may have led to sub-optimisation of the CAS as a whole, yet in this context it achieved successful outcomes. We therefore offer an important theoretically driven contribution by

positing that in the HL context a CAS must both react to and create its environment. It must therefore adapt and also create by developing bespoke approaches to each humanitarian relief operation. Underestimating how a humanitarian response reacts to and creates its environment could be a major reason why tools and techniques from commercial logistics do not always apply in a humanitarian context. This finding leads to our final proposition:

*Proposition 5: A humanitarian relief effort must react to and create its environment, therefore bespoke approaches to HL are essential.*

While there is an acknowledgement that people are drivers of dynamic SCs (Mangan et al. 2008), it has also been stated that HL research has a tendency to over-simplify situations (Apte 2009; Day et al. 2012). This could explain why there is insufficient research addressing the behavioural elements of HL, or in fact other complex logistics operations. Such operations could include expeditionary military logistics and SCs for large sporting events such as the Olympics or the Football World Cup. Complex logistics operations have to consider how to address elements of behavioural complexity to ensure a holistic and sustainable approach. It has previously been highlighted that behavioural studies in logistics and SC management could be beneficial (Tokar 2010), and our study and propositions provide a springboard for further work. Any concerted effort to improve HL and other complex logistics operations has to originate from a thorough understanding of the complexities of the HL organisations' response. It is not appropriate to ignore the complicating factors faced in practice if research is to be relevant (Day et al. 2012; Day 2014).

Due to the complex nature of the setting, and of the two HL responses examined in our case-study research, we show how each humanitarian response must react to and create its environment. While standardisation has its place, even within complex logistics operations, we cannot approach every humanitarian response in the same way. In tailoring approaches, and

ultimately solutions, to a given problem situation it is vital to consider its inherent behavioural complexity, e.g. agents' connectivity, inter and intra CAS competition, competing values of agents and willingness for shared learning, as we found in this study. Logistics research, within and beyond the confines of HL, all too often ignores the individuals involved and the interactions between them in favour of standardised approaches. In an era of volatility, uncertainty, complexity, and ambiguity, this mentality is no longer fit for purpose within HL, or indeed within wider SC research and practice.

## **7. Conclusions and research implications**

### ***7.1 Theoretical implications***

This study has presented a rich picture of two humanitarian responses, focussing on issues inherent to HL, rather than to a particular organisation. Our study makes two important theoretically driven contributions that have practical relevance. First, drawing on CAS theory, we illustrate the main characteristics of complexity in HL and show how complexity impacts the humanitarian response, thus extending our theoretical understanding of this complex operating environment. CAS have previously been used in SC literature (Choi et al. 2001; Pathak et al. 2007; Pathak et al. 2009), but have only received limited attention in HL (Day 2014). In general, there is a lack of engagement with theory in HL research (Oloruntoba et al. 2019). Our theoretical framing of the dimensions of a CAS offer a new way to conceptualise HL on the wider scale of humanitarian responses or even the entire sector. To attempt to solve problems within only one agency is a failure to understand interconnectedness which cannot adequately address challenges of complex logistics operations. Complex problems can only be approached holistically, with reductionist approaches yielding no or unsatisfactory results (Gell-Mann 1994). Research needs to acknowledge that modern logistics may not be suitable for study if the unit of analysis is a single organisation. This study has shown that while

differences between individuals and organisations exist, there are also over-arching issues that affect HL in particular responses irrespective of the organisational context. We have highlighted connectedness, self-organisation and maintaining neutrality. With this, we add to the growing body of research on HL by utilising empirical evidence (Kovács and Spens 2009; Tatham and Houghton 2011; Kovács et al. 2012; Pérouse de Montclos 2012; Wagner and Thakur-Weigold 2018). To tackle the issues examined, the establishment of an evidence base that reaches across organisational boundaries is vital.

### ***7.2 Managerial implications***

We have shown how HL needs to both react to and create its environment in order to thrive in this complex context. HL is a CAS that interacts extensively with its environment. Our findings suggest that managers in humanitarian organisations need to reassess the utility of tools and techniques borrowed from commercial SCs. Managers also need to take a more holistic perspective and develop interventions that are more likely to be effective, thereby building a bridge between commercial and HL practices. Particular attention should be paid to equipping the humanitarian response to react to and create its environment, and the acknowledgement that bespoke HL solutions are required to attain better performance.

### ***7.3 Limitations and future research directions***

Our study is not without its limitations, most significantly with the primary data collected. Given the importance of stakeholders that emerged from the primary data, only including actors from humanitarian organisations in the sample does not provide a comprehensive picture of the entire system. No beneficiaries, political decision makers, commercial suppliers, media representatives, or other stakeholders have been included in the sample. While such stakeholders might have limited direct involvement in HL, they have considerable influence.

Each case study also includes a limited number of interviews. While care was taken to represent a range of organisations and job roles, these interviews cannot claim to provide a complete picture of the humanitarian responses. The balance of organisational sizes represented in the sample skews towards larger organisations, which are likely to be more established, but could also be less flexible than smaller organisations. Furthermore, the majority of interviewees were male, including all of those identifying as logisticians. Future studies in this area should address the size and composition of samples.

Notwithstanding these limitations, our study draws on important qualitative findings to provide a rich picture of two highly complex HL contexts. By offering theoretically driven insights garnered from those working in the field, our study goes some way to addressing the limited empirical evidence base of HL and provides an important foundation for additional studies on this crucial topic.

## References

- Altay, N., & Pal, R. (2014). Information Diffusion among Agents: Implications for Humanitarian Operations. *Production and Operations Management*, 23(6), 1015–1027.
- Altay, N., Prasad, S., & Sounderpandian, J. (2009). Strategic planning for disaster relief logistics: lessons from supply chain management. *International Journal of Services Sciences*, 2(2), 142-161, doi:0.1504/IJSSCI.2009.024937.
- Anaya-Arenas, A. M., Renaud, J., & Ruiz, A. (2014). Relief distribution networks: A systematic review. *Annals of Operations Research*, 223(2014), 53-79, doi:10.1007/s10479-014-1581-y.
- Apte, A. (2009). *Humanitarian logistics: a new field of research and action* (Vol. 3, Foundations and Trends in Technology, Information and OM, Vol. 1). Hanover, MA: NOW Publishers.
- Balcik, B., Beamon, B. M., Krejci, C. C., Muramatsu, K. M., & Ramirez, M. (2010). Coordination in humanitarian relief chains: Practices, challenges and opportunities. [Article]. *International Journal of Production Economics*, 126(1), 22-34, doi:10.1016/j.ijpe.2009.09.008.
- Banomyong, R., Varadejsatitwong, P., & Oloruntoba, R. (2019). A systematic review of humanitarian operations, humanitarian logistics and humanitarian supply chain performance literature 2005 to 2016. *Annals of Operations Research*, 283(2019), 71–86, doi:10.1007/s10479-017-2549-5.
- Beamon, B. M., & Balcik, B. (2008). Performance measurement in humanitarian relief chains. *International Journal of Public Sector Management*, 21(1), 4-25, doi:10.1108/09513550810846087.
- Begun, J. W., Zimmermann, B., & Dooley, K. (2003). Health Care Organisations as Complex Adaptive Systems. In S. S. Mick, & M. E. Wyttenbach (Eds.), *Advances in Health Care Organization Theory*. San Francisco, CA: Jossey-Bass.
- Behl, A., & Dutta, P. (2019). Humanitarian supply chain management: a thematic literature review and future directions of research. *Annals of Operations Research*, 283(2019), 1001-1044, doi:10.1007/s10479-018-2806-2.
- Besiou, M., & Van Wassenhove, L. N. (2020). Humanitarian Operations: A World of Opportunity for Relevant and Impactful Research. *Manufacturing & Service Operations Management*, 22(1), doi:10.1287/msom.2019.0799.
- Bhakoo, V., & Choi, T. (2013). The iron cage exposed: Institutional pressures and heterogeneity across the healthcare supply chain. *Journal of Operations Management*, 31(6), 432-449, doi:10.1016/j.jom.2013.07.016.
- Blecken, A. (2010). Supply chain process modelling for humanitarian organizations. *International Journal of Physical Distribution and Logistics Management*, 40(8-9), 675-692, doi:10.1108/09600031011079328.
- Bowen, G. A. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal*, 9(2), 27-40, doi:10.3316/QRJ0902027.
- Brownlee, J. (2007). Complex Adaptive Systems. *CIS Technical Report*. Melbourne: Complex Intelligent Systems Laboratory, Centre for Information Technology Research, Faculty of Information Communication Technology, Swinburne University of Technology.
- Bryman, A. (2012). *Social research methods* (4th ed. ed.): Oxford: Oxford University Press.

- Cachon, G. P., Girotra, K., & Netessine, S. (2020). Interesting, Important, and Impactful Operations Management. *Manufacturing & Service Operations Management*, 22(1), 214-222, doi:10.1287/msom.2019.0813.
- Campus, P. F., Trucco, P., & Huatuco, L. H. (2019). Managing structural and dynamic complexity in supply chains: insights from four case studies. *Production Planning and Control*, in press, doi:10.1080/09537287.2018.1545952.
- Cassell, C., & Gummesson, E. (2006). Qualitative research in management: addressing complexity, context and persona. *Management Decision*, 44(2), 167-179, doi:10.1108/00251740610650175.
- Centre for Research on the Epidemiology of Disasters (2015). Disaster Profiles. [http://www.emdat.be/disaster\\_profiles/index.html](http://www.emdat.be/disaster_profiles/index.html). Accessed 17.04. 2019.
- Chandes, J., & Pache, G. (2010). Investigating humanitarian logistics issues: From operations management to strategic action. *Journal of Manufacturing Technology Management*, 21(3), 320-340, doi:10.1108/17410381011024313.
- Chapman, A. G., & Mitchell, J. E. (2018). A fair division approach to humanitarian logistics inspired by conditional value-at-risk. *Annals of Operations Research*, 262(2018), 133-151, doi:10.1007/s10479-016-2322-1.
- Charles, A., Lauras, M., & Van Wassenhove, L. (2010). A model to define and assess the agility of supply chains: building on humanitarian experience. *International Journal of Physical Distribution and Logistics Management*, 40(8-9), 722-741, doi:10.1108/09600031011079355.
- Choi, T. Y., Dooley, K. J., & Rungtusanatham, M. (2001). Supply networks and complex adaptive systems: Control versus emergence. [Article]. *Journal of Operations Management*, 19(3), 351-366, doi:10.1016/S0272-6963(00)00068-1.
- Christopher, M. (2005). *Logistics and Supply Chain Management: Creating Value-Adding Networks*. Harlow: Financial Times Prentice Hall.
- Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (4th ed.). Los Angeles, CA: Sage.
- DARA (2011). The Humanitarian Response Index: Focus on Haiti.
- Day, J. M. (2014). Fostering emergent resilience: the complex adaptive supply network of disaster relief. *International Journal of Production Research*, 52(7), 1970-1988, doi:10.1080/00207543.2013.787496.
- Day, J. M., Melnyk, S. A., Larson, P. D., Davis, E. W., & Whybark, D. C. (2012). Humanitarian and disaster relief supply chains: A matter of life and death. [Article]. *Journal of Supply Chain Management*, 48(2), 21-36, doi:10.1111/j.1745-493X.2012.03267.x.
- de Faria Cordeiro, K., Campos, M. L. M., & Borges, M. R. S. (2015). aDApTA: Adaptive approach to information integration in dynamic environments. *Computers in Industry*, 71(2015), 88-102, doi:10.1016/j.compind.2015.03.002.
- Denzin, N. K. (1970). *The research act: A theoretical introduction to sociological methods*. New Brunswick and London: AldineTransaction.
- Dooley, K., & Van de Ven, A. (1999). Explaining complex organizational dynamics. *Organization Science*, 10(3), 358-372, doi:10.1287/orsc.10.3.358.
- Dubey, R., Altay, N., & Blome, C. (2017). Swift trust and commitment: The missing links for humanitarian supply chain co-ordination? *Annals of Operations Research*, 1-19.
- Eisenhardt, K. M., & Graebner, M. E. (2007). Theory Building from Cases: Opportunities and Challenges. [Article]. *Academy of Management Journal*, 50(1), 25-32, doi:10.5465/AMJ.2007.24160888.
- Ellram, L. M. (1996). The use of the case study method in logistics research. [Article]. *Journal of Business Logistics*, 17(2), 93-138.

- Faulkner, B. (2001). Towards a framework for tourism disaster management. *Tourism Management*, 22(2), 134-147, doi:10.1016/S0261-5177(00)00048-0.
- Flyvbjerg, B. (2013). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry*, 12(2), 219-245.
- Gao, X. (2019). A bi-level stochastic optimization model for multi-commodity rebalancing under uncertainty in disaster response. *Annals of Operations Research*, 283(2019), 1-34, doi:10.1007/s10479-019-03506-6.
- Gell-Mann, M. (1994). *The Quark and the Jaguar: Adventures in the Simple and the Complex*. London: Little Brown.
- Goldstein, J. (1994). *The Unshackled Organization*. Portland, OR: Productivity Press.
- Gonçalves, P. (2008). System dynamics modeling of humanitarian relief operations. *MIT Sloan School Working Paper*, 4704-08.
- Gonçalves, P., & Castañeda, J. A. (2018). Stockpiling supplies for disaster response: An experimental analysis of prepositioning biases. *Production Planning and Control*, 29(14), 1207-1219, doi:10.1080/09537287.2018.1542173.
- Guba, E., & Lincoln, Y. (1994). Competing paradigms in qualitative research. In N. K. Denzin, & Y. S. Lincoln (Eds.), *Handbook of Qualitative Research* (pp. 105-117). London: Sage.
- Gunasekaran, A., Dubey, R., Fosfo Wamba, S., Papadopoulos, T., Hazen, B., T., et al. (2018). Bridging humanitarian operations management and organisational theory. *International Journal of Production Research*, 56(21), 6735-6740, doi:10.1080/00207543.2018.1551958.
- Gupta, S., Altay, N., & Luo, Z. (2019). Big data in humanitarian supply chain management: a review and further research directions. *Annals of Operations Research*, 283(2019), 1153-1173, doi:10.1007/s10479-017-2671-4.
- Gustavsson, L. (2003). Humanitarian logistics: context and challenges. *Forced Migration Review*, 18(1), 6-8.
- Haiti Logistics Cluster (2010). Operation: Haiti Earthquake Response Concept of Operations. Logistics Cluster.
- Handayani, D., Sopha, B. M., Hartono, B., & Herliansyah, M. K. (2017). The behavioural rules of people during disaster emergency evacuation: a case study of mount merapi eruption in Indonesia. *Journal of Engineering and Applied Sciences*, 12(21), 5443-5451, doi:10.3923/jeasci.2017.5443.5451.
- Harrington, L. H., Boyson, S., & Corsi, T. M. (2011). *X-SCM: The New Science of X-treme Supply Chain Management*. New York, NY: Routledge.
- Heaslip, G., & Barber, E. (2014). Using the military in disaster relief: systemising challenges and opportunities. *Journal of Humanitarian Logistics & Supply Chain Management*, 4(1), 60-82, doi:10.1108/JHLSCM-03-2013-0013.
- Heaslip, G., Sharif, A. M., & Althonayan, A. (2012). Employing a systems-based perspective to the identification of inter-relationships within humanitarian logistics. [Article]. *International Journal of Production Economics*, 139(2), 377-392, doi:10.1016/j.ijpe.2012.05.022.
- Hilhorst, D. (2002). Being good at doing good? Quality and accountability of humanitarian NGOs. *Disasters*, 26(3), 193-212, doi:10.1111/1467-7717.00200.
- Holguín-Veras, J., Jaller, M., & Wachtendorf, T. (2012). Comparative performance of alternative humanitarian logistic structures after the Port-au-Prince earthquake: ACEs, PIEs, and CANs. [Article]. *Transportation Research Part A*, 46(10), 1623-1640, doi:10.1016/j.tra.2012.08.002.
- Holland, J. H. (1995). *Hidden Order: How Adaptation Builds Complexity*. Reading, MA; Wokingham, England: Addison-Wesley.

- Inter-Agency Standing Committee (2010). Response to the Humanitarian Crisis in Haiti: Following the 12 January 2010 Earthquake.
- International Development Committee (2011). The Humanitarian Response to the Pakistan Floods. <http://www.publications.parliament.uk/pa/cm201012/cmselect/cmintdev/615/61504.htm>. Accessed 17.04. 2019.
- Jabbour, C. J. C., Sobreiro, V. A., de Sousa Jabbour, A. B. L., Campos, d. S., L. M., M., E. B., & Renwick, D. W. S. (2017). An analysis of the literature on humanitarian logistics and supply chain management: paving the way for future studies. *Annals of Operations Research*, 283(2019), 289-307, doi:10.1007/s10479-017-2536-x.
- Jahre, M., & Heigh, I. (2008). Does failure to fund preparedness mean donors must be prepared to fund failure in humanitarian supply chains? *Beyond Business Logistics. NOFOMA Conference Proceedings, Helsinki, Finland* (pp. 265-282).
- Johnson, P., Buehring, A., Cassell, C., & Symon, G. (2006). Evaluating qualitative management research: Towards a contingent criteriology. *International Journal of Management Reviews*, 8(3), doi:10.1111/j.1468-2370.2006.00124.x.
- Kauffman, S. A. (1995). *At Home in the Universe: The Search for Laws of Self-Organization and Complexity*. New York; Oxford: Oxford University Press.
- Kirsch, T., Siddiqui, M. A., Perrin, P. C., Robinson, W. C., Sauer, L. M., & Doocy, S. (2013). Satisfaction with the humanitarian response to the 2010 Pakistan floods: a call for increased accountability to beneficiaries. *Emergency Medicine Journal*, 30(7), 565-571, doi:10.1136/emered-2012-201226.
- Kovács, G., & Moshtari, M. (2019). A roadmap for higher research quality in humanitarian operations: A methodological perspective. *European Journal of Operational Research*, 276(2), 395-408, doi:10.1016/j.ejor.2018.07.052.
- Kovács, G., & Spens, K. (2008). Humanitarian logistics revisited. In J. Stentoft Arlbjorn, A. Halldorsson, M. Jahre, & K. Spens (Eds.), *Northern Lights in Logistics and Supply Chain Management* (pp. 217-232). Copenhagen: Copenhagen Business School Press.
- Kovács, G., & Spens, K. (2009). Identifying challenges in humanitarian logistics. *International Journal of Physical Distribution & Logistics Management*, 39(6), 506-528, doi:10.1108/09600030910985848.
- Kovács, G., & Spens, K. (2011). Humanitarian logistics and supply chain management: the start of a new journal. *Journal of Humanitarian Logistics & Supply Chain Management*, 1(1), 5-14, doi:10.1108/20426741111123041.
- Kovács, G., & Spens, K. M. (2007). Humanitarian logistics in disaster relief operations. [Article]. *INTERNATIONAL JOURNAL OF PHYSICAL DISTRIBUTION & LOGISTICS MANAGEMENT*, 37(2), 99-114, doi:10.1108/09600030710734820.
- Kovács, G., & Tatham, P. (2010). What is special about a humanitarian logistician? A survey of logistic skills and performance. *Supply Chain Forum*, 11(3), 32-41, doi:10.1080/16258312.2010.11517238.
- Kovács, G., Tatham, P., & Larson, P. D. (2012). What Skills Are Needed to be a Humanitarian Logistician? [Article]. *Journal of Business Logistics*, 33(3), 245-258, doi:10.1111/j.2158-1592.2012.01054.x.
- Krejci, C. C. (2015). Hybrid simulation modeling for humanitarian relief chain coordination. *Journal of Humanitarian Logistics and Supply Chain Management*, 5(3), 325-347, doi:10.1108/JHLSCM-07-2015-0033.
- Kreye, M. E., Roehrich, J. K., & Lewis, M. A. (2015). Servitising manufacturers: the impact of service complexity and contractual and relational capabilities. *Production Planning and Control*, 26(14-15), 1233-1246, doi:10.1080/09537287.2015.1033489.

- Kunz, N., & Reiner, G. (2012). A meta-analysis of humanitarian logistics research. *Journal of Humanitarian Logistics & Supply Chain Management*, 2(2), 116-147, doi:10.1108/20426741211260723.
- Kunz, N., Reiner, G., & Gold, S. (2014). Investing in disaster management capabilities versus pre-positioning inventory: A new approach to disaster preparedness. *International Journal of Production Economics*, 157, 261-272, doi:<http://dx.doi.org/10.1016/j.ijpe.2013.11.002>.
- L'Hermitte, C., Bowles, M., Tatham, P., & Brooks, B. (2015). An integrated approach to agility in humanitarian logistics. *Journal of Humanitarian Logistics and Supply Chain Management*, 5(2), 209-233, doi:10.1108/JHLSCM-04-2014-0016.
- Langdon, C. S., & Sikora, R. T. (2006). Conceptualizing co-ordination and competition in supply chains as complex adaptive system. *Information systems and e-business management*, 4(1), 71-81, doi:10.1007/s10257-005-0005-6.
- Larson, P. D., & Foropon, C. (2018). Process improvement in humanitarian operations: an organisational theory perspective. *International Journal of Production Research*, 56(21), 6828-6841, doi:10.1080/00207543.2018.1424374.
- Lettieri, E., Masella, C., & Radaelli, G. (2009). Disaster management: findings from a systematic review. *Disaster Prevention and Management*, 18(2), 117-136, doi:10.1108/09653560910953207.
- Lewin, R. (1993). *Complexity: Life at the Edge of Chaos*. London: Dent.
- Li, G., Yang, H., Sun, L., Ji, P., & Feng, L. (2010). The evolutionary complexity of complex adaptive supply networks: A simulation and case study. *International Journal of Production Economics*, 124(2), doi:10.1016/j.ijpe.2009.11.027.
- Lincoln, Y. S., & Guba, E. G. (1986). But is it rigorous? Trustworthiness and authenticity in naturalistic evaluation. *New Directions for Evaluation*, 1986(30), 73-84.
- Lincoln, Y. S., Lynham, S. A., & Guba, E. G. (2013). Paradigmatic controversies, contradictions, and emerging confluences revisited. In N. K. Denzin, & Y. S. Lincoln (Eds.), *The landscape of qualitative research*. London: Sage.
- Madiwale, A., & Virk, K. (2011). Civil–military relations in natural disasters: a case study of the 2010 Pakistan floods. *International Review of the Red Cross*, 93(884).
- Makepeace, D., Tatham, P. H., & Wu, Y. (2017). Internal integration in humanitarian supply chain management: Perspectives at the logistics-programmes interface. *Journal of Humanitarian Logistics and Supply Chain Management*, 7(1), 26-56, doi:10.1108/JHLSCM-12-2015-0042.
- Mangan, J., Lalwani, C., & Butcher, T. (2008). *Global Logistics and Supply Chain Management*. Chichester: Wiley.
- Margesson, R., & Taft-Morales, M. (2010). Haiti Earthquake: Crisis and Response. Washington D.C., USA: Congressional Research Service.
- McCarthy, I. P., Tsinopoulos, C., Allen, P., & Rose-Anderssen, C. (2006). New product development as a complex adaptive system of decisions. *Journal of Product Innovation Management*, 23(5), 437-456, doi:10.1111/j.1540-5885.2006.00215.x.
- McEntire, D. A. (2004). Development, disasters and vulnerability: a discussion of divergent theories and the need for their integration. *Disaster Prevention & Management*, 13(3), 193-198.
- McLachlin, R., & Larson, P. D. (2011). Building humanitarian supply chain relationships: lessons from leading practitioners. *Journal of Humanitarian Logistics & Supply Chain Management*, 1(1), 32-49, doi:10.1108/20426741111122402.
- Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook*. Thousand Oaks, CA: Sage.

- Moore, D. M., & Taylor, D. H. (2011). Humanitarian logistics professionalism. In M. Christopher, & P. Tatham (Eds.), *Humanitarian Logistics Meeting the Challenges of Preparing for and Responding to Disasters*. London, UK: Kogan Page Limited.
- Moshtari, M. (2016). Inter-organizational fit, relationship management capability, and collaborative performance within a humanitarian setting. *Production and Operations Management*, 25(9), 1542-1557, doi:10.1111/poms.12568.
- Naor, M., Dey, A., Goldstein, S. M., & Rosen, Y. (2018). Civilian-military pooling of health care resources in Haiti: A theory of complementarities perspective. *International Journal of Production Research*, 56(21), 6741-6757, doi:10.1080/00207543.2017.1355121.
- Natarajarathinam, M., Capar, I., & Narayanan, A. (2009). Managing supply chains in times of crisis: a review of literature and insights. *International Journal of Physical Distribution & Logistics Management*, 39(7), 535-573, doi:10.1108/09600030910996251.
- Office of the Special Envoy for Haiti, U. (2013). New York conference recovery pledge status and modalities as of December 2012 in USD millions. New York, NY, USA: UN Office of the Special Envoy for Haiti.
- Olaogbebikan, J. E., & Oloruntoba, R. (2017). Similarities between disaster supply chains and commercial supply chains: A SCM process view. *Annals of Operations Research*, 259(1-2), 1-26, doi:10.1007/s10479-017-2690-1.
- Oloruntoba, R., & Gray, R. (2009). Customer service in emergency relief chains. *International Journal of Physical Distribution & Logistics Management*, 39(6), 486-495, doi:10.1108/09600030910985839.
- Oloruntoba, R., Hossain, G. F., & Wagner, B. (2019). Theory in humanitarian operations research. *Annals of Operations Research*, 283(2019), 543-560, doi:10.1007/s10479-016-2378-y.
- Oloruntoba, R., & Kovács, G. (2015). A commentary on agility in humanitarian aid supply chains. *Supply Chain Management: An International Journal*, 20(6), 708-716, doi:10.1108/SCM-06-2015-0244.
- Pateman, H., Hughes, K., & Cahoon, S. (2013). Humanizing Humanitarian Supply Chains: A Synthesis of Key Challenges. *The Asian Journal of Shipping and Logistics*, 29(1), 81-102, doi:10.1016/j.ajsl.2013.05.005.
- Pathak, S. D., Day, J. M., Nair, A., Sawaya, W. J., & Kristal, M. M. (2007). Complexity and Adaptivity in Supply Networks: Building Supply Network Theory Using a Complex Adaptive Systems Perspective. [Article]. *Decision Sciences*, 38(4), 547-580, doi:10.1111/j.1540-5915.2007.00170.x.
- Pathak, S. D., Dilts, D. M., & Mahadevan, S. (2009). Investigating population and topological evolution in a complex adaptive supply network. *The Journal of Supply Chain Management: A Global Review of Purchasing and Supply*, 45(3), 54-67, doi:10.1111/j.1745-493X.2009.03171.x.
- Pedraza-Martinez, A. J., Stapleton, O., & Van Wassenhove, L. N. (2013). On the use of evidence in humanitarian logistics research. [Article]. *Disasters*, 37, S51-S67, doi:10.1111/disa.12012.
- Pérouse de Montclos, M.-A. (2012). Humanitarian action in developing countries: Who evaluates who? [Article]. *Evaluation and Program Planning*, 35(1), 154-160, doi:10.1016/j.evalprogplan.2010.11.005.
- Pettit, S., & Beresford, A. (2009). Critical success factors in the context of humanitarian aid supply chains. [Article]. *International Journal of Physical Distribution & Logistics Management*, 39(6), 450-468, doi:10.1108/09600030910985811.
- Polastro, R., Nagrah, A., Steen, N., & Zafar, F. (2011). Inter-Agency Real Time Evaluation of the Humanitarian Response to Pakistan's 2010 Flood Crisis. DARA.

- Polishuk, S. (1998). Secrets, lies and misremembering: the perils of oral history interviewing. *Frontiers: A Journal of Women Studies*, 19(3), 14-23, doi:10.2307/3347085.
- Prigogine, I., & Stengers, I. (1984). *Order out of Chaos: Man's New Dialogue with Nature*. London: Heinemann.
- Richey, R. G. (2009). The supply chain crisis and disaster pyramid A theoretical framework for understanding preparedness and recovery. *International Journal of Physical Distribution and Logistics Management*, 39(7), 619-628, doi:10.1108/09600030910996288.
- Ritchie, B. W. (2004). Chaos, crises and disasters: a strategic approach to crisis management in the tourism industry. *Tourism Management*, 25(6), 669-683, doi:10.1016/j.tourman.2003.09.004.
- Robson, C. (2011). *Real world research: a resource for users of social research methods in applied settings* (3rd ed.). Chichester: Wiley.
- Sandwell, C. (2011). A qualitative study exploring the challenges of humanitarian organisations. *Journal of Humanitarian Logistics & Supply Chain Management*, 1(2), 132-146, doi:10.1108/20426741111158430.
- Saunders, M., Lewis, P., & Thornhill, A. (2006). *Research Methods for Business Students* (4th ed.). Harlow: Financial Times Prentice Hall.
- Schein, E. (1994). *Organizational Culture and Leadership*. San Francisco, CA: Jossey-Bass.
- Schiffing, S., & Piecyk, M. (2014). Performance measurement in humanitarian logistics: a customer-oriented approach. *Journal of Humanitarian Logistics and Supply Chain Management*, 4(2), 198-221, doi:10.1108/JHLSCM-08-2013-0027.
- Schneider, M., & Somers, M. (2006). Organizations as complex adaptive systems: Implications of Complexity Theory for leadership research. *Leadership Quarterly*, 17(4), 351-365, doi:10.1016/j.leaqua.2006.04.006.
- Schoenherr, T., Modi, S. B., Benton, C., W., Carter, C. R., Choi, T. Y., et al. (2012). Research opportunities in purchasing and supply management. *International Journal of Production Research*, 50(16), 4556-4579.
- Seybolt, T. B. (2009). Harmonizing the humanitarian aid network: Adaptive change in a complex system. *International Studies Quarterly*, 53(4), 1027-1050, doi:10.1111/j.1468-2478.2009.00567.x.
- Shafiee, M. E., & Berglund, E. Z. (2016). Agent-based modeling and evolutionary computation for disseminating public advisories about hazardous material emergencies. *Computers, Environment and Urban Systems*, 57(2016), 12-25, doi:10.1016/j.compenvurbsys.2016.01.001.
- Singapore Red Cross (2010). Pakistan Floods: The Deluge of Disaster - Facts & Figures as of 15 September 2010. <http://reliefweb.int/report/pakistan/pakistan-floodsthe-deluge-disaster-facts-figures-15-september-2010>. Accessed 17.04. 2019.
- Smith, R. C. (2001). Analytic strategies for oral history interviews. In J. F. Gubrium, & J. A. Holstein (Eds.), *Handbook of Interview Research* (pp. 711-731). Thousand Oaks, CA: Sage.
- Stake, R. E. (2000). The Case Study Method in Social Inquiry. In R. Gomm, M. Hammersley, & P. Foster (Eds.), *Case Study Method* (pp. 19-26). London: SAGE Publications Ltd.
- Stauffer, J. M., Pedraza-Martinez, A. J., Yan, L., & Van Wassenhove, L. N. (2018). Asset supply networks in humanitarian operations: A combined empirical simulation approach. *Journal of Operations Management*, 63, 44-58, doi:10.1016/j.jom.2018.07.002.
- Stewart, M., & Ivanov, D. (2019). Design redundancy in agile and resilient humanitarian supply chains. *Annals of Operations Research*, 283(2019), 1-27, doi:10.1007/s10479-019-03507-5.

- Stoddard, A. (2003). *Humanitarian NGOs: Challenges and Trends*. New York, NY: Humanitarian Policy Group.
- Stuart, I., McCutcheon, D., Handfield, R., McLachlin, R., & Samson, D. (2002). Effective case research in operations management: a process perspective. [Article]. *Journal of Operations Management*, 20(5), 419-433, doi:10.1016/S0272-6963(02)00022-0.
- Surana, A., Kumara, S., Raghavan, U. N., & Greaves, M. (2005). Supply-chain networks: A complex adaptive systems perspective. [Article]. *International Journal of Production Research*, 43(20), 4235-4265, doi:10.1080/00207540500142274.
- Tatham, P., & Houghton, L. (2011). The wicked problem of humanitarian logistics and disaster relief aid. *Journal of Humanitarian Logistics & Supply Chain Management*, 1(1), 15-31, doi:10.1108/20426741111122394.
- Tatham, P., Spens, K., & Taylor, D. (2009). Development of the academic contribution to humanitarian logistics and supply chain management. *Management Research News*, 32(11), 1-11, doi:10.1108/mrn.2009.02132kaa.001.
- Tatham, P. H., & Pettit, S. J. (2010). Transforming humanitarian logistics: the journey to supply network management. [Editorial Material]. *International Journal of Physical Distribution & Logistics Management*, 40(8-9), 609-622, doi:10.1108/09600031011079283.
- Thomas, A. (2004). Elevating humanitarian logistics. *International Aid & Trade Review*, pp. 102-106.
- Thomas, A., & Mizushima, M. (2005). Logistics training: necessity or luxury? *Forced Migration Review*, 60-61.
- Thomas, A. S., & Kopczak, L. R. (2005). *From Logistics to Supply Chain Management: The Path Forward in the Humanitarian Sector*. San Francisco, CA: Fritz Institute.
- Tokar, T. (2010). Behavioural research in logistics and supply chain management. *International Journal of Logistics Management*, 21(1), 89-103, doi:10.1108/09574091011042197.
- Tomasini, R. M., & Van Wassenhove, L. N. (2009). From preparedness to partnerships: case study research on humanitarian logistics. *International Transactions in Operational Research*, 16(5), 549-559, doi:10.1111/j.1475-3995.2009.00697.x.
- Turkeš, R., Cuervo, D. P., & Sörensen, K. (2017). Pre-positioning of emergency supplies: does putting a price on human life help to save lives? *Annals of Operations Research*, 283(2017), 865–895, doi:10.1007/s10479-017-2702-1.
- United States Southern Command (2010). Narrative History of Operation Unified Response (November 1, 2010).
- Vaillancourt, A. (2016). A theoretical framework for consolidation in humanitarian logistics. *Journal of Humanitarian Logistics & Supply Chain Management*, 6(1), 2-24, doi:10.1108/JHLSCM-01-2015-0001.
- Van Dyke Parunak, H. (1997). "Go to the ant": Engineering principles from natural multi-agent systems. *Annals of Operations Research*, 75(1997), 69-101, doi:10.1023/A:1018980001403.
- Van Wassenhove, L. N. (2006). Blackett Memorial Lecture - Humanitarian aid logistics: supply chain management in high gear. [Article]. *Journal of the Operational Research Society*, 57(5), 475-489, doi:10.1057/palgrave.jors.2602125.
- Voss, C., Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. [Article]. *International Journal of Operations and Production Management*, 22(2), 195-219, doi:10.1108/01443570210414329.
- Wagner, S. M., & Thakur-Weigold, B. (2018). Supporting collaboration in humanitarian supply chains—insights from a design science project. *Production Planning and Control*, 29(14), 1130-1144, doi:10.1080/09537287.2018.1542175.

- Walker, P. (2004). What does it mean to be a professional humanitarian? *The Journal of Humanitarian Assistance*, 14, 5-10.
- World Bank Data (2020). World Bank Open Data. <https://data.worldbank.org>. Accessed 15th April 2020.
- Wycisk, C., McKelvey, B., & Hülsmann, M. (2008). "Smart parts" supply networks as complex adaptive systems: Analysis and implications. *International Journal of Physical Distribution and Logistics Management*, 38(2), doi:10.1108/09600030810861198.
- Yao, X., Huang, R. T., Song, M. L., & Mishra, N. (2018). Pre-positioning inventory and service outsourcing of relief material supply chain. *International Journal of Production Research*, 56(21), 6859-6871, doi:10.1080/00207543.2018.1495853.
- Yin, R. K. (2014). *Case Study Research: Design and Methods* (5th ed.). Thousand Oaks, CA: Sage.