Network Coordination of Relief Logistics and Its Impact on Field Operations in Emergency Health Services: The Ebola Crisis in Liberia in 2014

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Network Coordination of Relief Logistics and Its Impact on Field Operations in Emergency Health Services: The Ebola Crisis in Liberia in 2014

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This research aims to answer the following question: What are the major coordination features and strategies of a humanitarian relief logistics system that will improve the entire response operation where a great number of diverse types of participating organizations engage in collective action under uncertain complex situations? This research investigates a relief logistics network during the Ebola crisis in Liberia 2014 as a case to analyze the evolution process of a humanitarian relief logistics system to meet emerging needs in a changing situation. Based on the complex adaptive system framework, this case is analyzed with an institutional analysis and development framework, institutional collective action, social networks, and theory of fields. This system evolution process is decomposed with two different levels: individual organizational behaviors in developing partnerships and collective action structures derived by organizational partnerships. As a core mechanism of a system evolution, the changes of coordination manners play a critical role in leading organizational choices of partners, in turn, re-structuring collective action structure. A set of data was collected by mixed methods, including network coding, semi-structured interviews, and documentation reviews. Then, this research utilized documentary analysis, logistics regression analysis, descriptive/statistical social network analyses, and qualitative analysis based on grounded theory.

By demonstrating a complex phenomenon into different levels of analyses, this research showed the evolution process of each level not only independently in parallel but also interactively. Findings suggest that a county level as a meso-level of a society plays a central role in engaging

diverse participating organizations across different operational levels into a face-to-face coordination process. Face-to-face coordination plays an active role in establishing a mutual learning process among diverse organizations to reduce perceptive gaps caused by environmental and organizational differences. Without overcoming those perceptive gaps, participating organizations fail to develop new collective rules to adapt and meet emerging needs in a fast-changing environment. This research suggests policy recommendations that can manage the contextual, structural, procedural, and perceptual impediments, and enhance the value of the collective action systems in policy and practice.

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1.0 Introduction

The number of natural disasters has increased in the last decades and is expected to keep increasing due to climate change. According to the OFDA/ CRED International Disaster Database (EMDAT, 2019), the number of disasters in the world has steadily grown since 1900 and began peaking in the 2000s. Since the year 2000, over 1 million people worldwide have died from natural disasters, with the cost of damage estimated at over $1.7 trillion (Guha-Sapir, Below, & Hoyois, 2015).

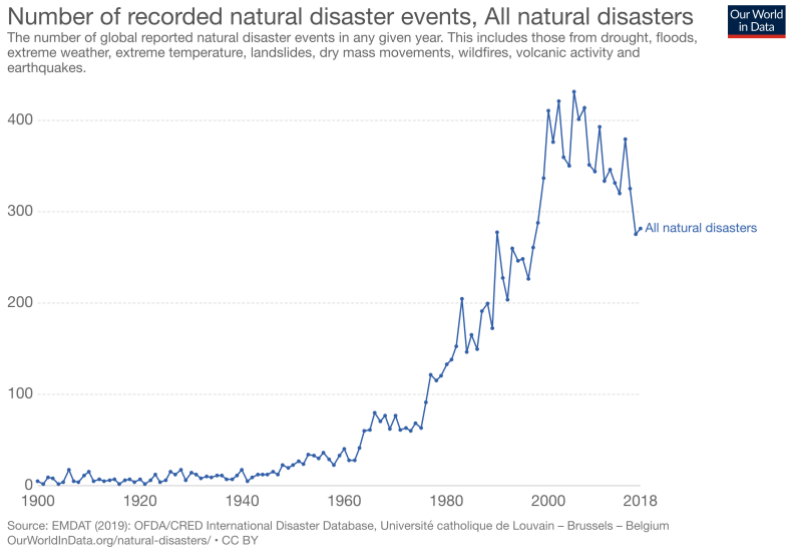


Figure 1 Number of Recorded Natural Disaster Events

However, the damage from disasters is not equally distributed across the globe. Conditions of environmental degradation and of social marginalization have amplified the damage in vulnerable areas and under-developed countries. A variety of social, economic, political, and cultural factors enforce vulnerable groups of people to settle down in a disaster-prone area. This trend causes marginalized communities to be concentrated in disaster-prone areas (Benson, Twigg, & Myers, 2001). United Nations Development Programme (UNDP) (2004) reports that more than half of all reported casualties occurred in vulnerable social

groups, even though these groups of people accounted for only a tenth of the entire groups exposed to natural hazards. The same study estimates that nearly 85% of the people vulnerable to natural hazards live in medium and low human development countries. Even in the same country, people living in poverty have higher vulnerability to a risk; one-third of the entire damage incurred by tsunamis were found in poor population who lived under the poverty-line (Oxfam, 2005). Unfortunately, these poor families who live in a physically and geographically vulnerable area have the least access to resources to prepare for hazards due to a lack of knowledge and access to political power (UN/ISDR, 2004; Dayton-Johnson, 2004).

In response to the increase of severe disasters and huge gaps in under-resourced risk-prone areas, increasing numbers of organizations have participated in creating an international collaborative effort in disaster sites. For the last 10 years, the number of emergency humanitarian workers worldwide has grown at a rate of 6 %. Currently, more than 201,000 people are estimated to work in the field of international emergency response (Beiser, 2010, p.3). Over 700 organizations from 40 countries participated in the 2004 Indonesia tsunami response (Chia, 2006) and 3,000-10,000 organizations from all over the world participated in 2010 Haiti earthquake response (Kristoff & Panarelli, 2010). Those organizations who participate in an international response operation seek to contribute physical and human resources to effectively increase operational performance. However, in addition to the complexity of the disasters, this rapidly growing and increasingly diverse number of disaster response organizations makes the entire response operation more complex. This highlights the urgent need of a more effective international coordination system to drive a successful collaboration.

In response to a disaster, a central goal of coordination is how to manage diverse resources in an efficient manner. Disaster operations compete with time. A late arrival of appropriate resources to the field increases the loss of lives and properties because response

operations will be delayed until they have enough resources to deal with the situation. As the types and number of participating organizations increase in a response operation, the quantity of resources increases while the quality of the resources varies. Many donors bring resources, which they perceive to be necessary, even before major coordinators' demand assessment of required resources to support response operations. If a certain type of disaster destroys a transportation system in affected areas, which are socially or geographically isolated, the response operations become even more complex (Thomas & Kopczak, 2005). Complex response situations require a heavier coordination of how to predict uncertain demands of resources, how to sort out diverse resources, how to allocate resources in order to assist certain types of recipients, and how to deliver those resources to the affected areas (Long and Wood, 1995).

This research aims to address the following question:

What are the major coordination features and strategies of a humanitarian relief logistics system that will improve the entire response operation where a great number of diverse types of participating organizations engage in collective action under uncertain complex situations?

The Fritz Institute defined humanitarian relief logistics as "the process of planning, implementing and controlling the efficient, cost-effective 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 alleviating the suffering of vulnerable people" (Thomas & Kopczak, 2005, p.2). This definition indicates that the coordination of humanitarian relief logistics coordinates the entire response operations from beginning to end. This response should cover from **a)** a planning stage—how to procure and bring resources into a nation from an international level, **b)** an implementing stage—how to sort out, store, and allocate resources at a national level,

and **c)** a closing stage—how to keep delivering allocated resources without disruptions to an affected area.

This research seeks a way to improve the performance of a humanitarian relief logistics system while highlighting the contribution of humanitarian relief logistics in a disaster response operation. To address those research questions, first, this research diagnoses the current problems both in the field and in research approaches. The diagnosis will help to find core challenges of humanitarian relief logistics embedded in the context of the disaster management approach. This section introduces and reviews the current international relief logistics system established by an international disaster management framework and the research trends. By comparing the field and theoretical approaches, I will identify 1) major undermining issues in the performance of humanitarian relief logistics and 2) research gaps, which are not yet filled, to meet the real needs in the field. Finally, I will suggest a research plan and strategies to fill such gaps, which ultimately answer the research questions above in detail.

1.1 The Cluster System: International Coordination Framework

To meet this urgent need, the United Nations has taken a leadership role in developing the cluster system as an international coordination framework in response to humanitarian crises. The cluster system refers specifically to the humanitarian task-focused clusters developed as a concept on the basis of the Humanitarian Response Review of 2005 (Adinolfi, Bassiouni, Lauritzsen, & Williams, 2005) endorsed by the Inter-agency standing committee (IASC). This system aims to promote international coordination mechanisms which bring all relevant actors together in order to strengthen coordination among humanitarian actors and between the humanitarian actors and the government of the afflicted nation. This comprehensive coordination is expected to create inter-organizational collaboration to address

the gaps in the emergency response (ILC, 2009). This current coordination mechanism consists of two different perspectives: division of labor and coordinating level.

The cluster system clarifies the division of labor among organizations and better defines their roles and responsibilities within the different clusters of the response. There are 11 clusters of operation: Agriculture, Camp Coordination/Management, Early Recovery, Education, Emergency Shelter, Emergency Telecommunications, Health, Logistics, Nutrition, Protection, Water, Sanitation and Hygiene. Each cluster has a designated leading organization that coordinates participating organizations within the cluster and is coordinated among other leading organizations from different clusters. For example, a health cluster is led by the World Health Organization (WHO) and a logistics cluster is led by the World Food Program (WFP). The cluster system has parallels with a loosely organized network composed with organizations that serve particular responsibilities to operate the network (Jensen & Hertz, 2016). However, the tasks in the cluster system vary according to the type of disasters. Each type of disaster requires different types of assistance and different levels of urgency for these cluster tasks. Not all clusters are activated in response to a certain disaster. Also, the tasks are determined by participating organizations in each cluster to fill the current gap. Because participation in the cluster system is on a voluntary basis, the number and types of participating organizations vary from time to time. The different participating organizations bring different types of skills and resources, which substantially determine specific set-up of particular missions for these clusters. As a result, even for the same type of disasters, the main task of each cluster is very instructive depending on the practical experiences of the participating organizations as well as each phase of the response operations.

The cluster system plans a two-level coordination structure. The global level coordination is to strengthen system-wide preparedness with technical and advisory support. The major duty of the global level coordination is to designate a leading organization for

coordination. For public health crises like SARS, MERS, or AIDs, the cluster system is led by the World Health Organization (WHO). For other humanitarian crises, like natural disasters, civil conflicts, or refugee displacements, the cluster system is led by the UN office for the Coordination of Humanitarian Affairs (UN OCHA) and/or the United Nations Development Programme (UNDP). These leading organizations develop a strategic plan in response to a crisis with the leading organizations from all clusters. The country level coordination aims to create a more coherent and effective response system in the crisis field where different types of organizations come to support response operations. Particular clusters are set up in response to the specific needs in a certain crisis at the country level. A major responsibility of the cluster coordination at the country level is to strengthen local capacities through close coordination with local civil societies and authorities at the local and national level, along with other relevant stakeholders. The national authority of an affected country should play a primary role in planning, initiating, coordinating, and implementing response plans (ILC, 2009).

1.2 International Policy Framework: Disaster Risk Management Vs. Health Risk Management

A major disaster preparedness program includes the establishment of appropriate coordination mechanisms based on the cluster system, which indicates sectors/clusters, leadership and partners in the pre-disaster phase. The United Nations International Strategy for Disaster Reduction (UN ISDR) system provides a strategic roadmap for all global stakeholders to prepare and support cluster coordination before and during a crisis. This system aims to create strong cooperation between countries and the UN agencies in the framework of the International Strategy for Disaster Risk Reduction (ISDR) during the pre-disaster phase. The Hyogo Framework for Action 2005-2015 established by the UN ISDR set the roadmap for

concerted action towards disaster risk reduction by the ISDR system (A/RES/54/219, A/RES/56/195, A/RES/59/233). The Hyogo Framework as a guide to "Multi-hazard management" served to prepare and coordinate for a wide range of disasters, excluding health risks but including "Cyclone wind and surge, tsunami, flood, volcano, [and] agriculture" (UN/ISDR, 2014, p.61), which could potentially cause a humanitarian crisis for vulnerable populations. Adopted by 168 governments in 2005, the Hyogo Framework as the overall coordination mechanism, paved the foundation to create the Global Platform for Disaster Risk Reduction by meeting every 2 years. It is the main global venue for member states and other stakeholders to assess progress made in the implementation of the Hyogo Framework for Action. This regular coordination would ultimately strengthen the coordination among participating organizations including member states and other stakeholders during a crisis. Under the Hyogo Framework, the UN OCHA plays a leadership role in promoting and coordinating humanitarian assistance delivered by international and national partners during preparedness and response phases (ILC, 2009).

Public health risks have been separately managed by the World Health Organization (WHO). The International Health Regulation (IHR) established in 2005 has served as the code of international regulations for the control of transboundary infectious diseases. The IHR described the WHO's major responsibilities as 1) a contact point at a regional level, 2) a leading coordinator for global surveillance and assessment of significant public health risks, 3) a provider of public health information to state parties, 4) a supporter for states parties to assess their existing national public health capacities and to strengthen their core public health system for surveillance and response, 5) a policy maker of international policy when there is an international concern for public health emergency, and 6) a technical recommender to member states by providing measures for surveillance, prevention, and control of public health emergencies in response to international concern (Jones, 2011). The IHR has played an

important role in strengthening legitimacy and discretion for the WHO to detect, investigate, respond, and control a recognized health issue. To operate such responsibilities in practice, the WHO required a comprehensive framework to identify roles and tasks of relevant organizations and guide the management in coordinating all participating organizations in response to an emergency health issue. The WHO's emergency response framework was introduced in 2013 (WHO, 2013).

However, there is an argument about whether a public health crisis should be considered as a separate issue from a humanitarian relief operation. The consequence of a disaster or public health outbreak does not result in an incident/risk itself; rather, the consequence is a result of the integration of the risk with socio-economic conditions. First, the recent disasters could not be clearly classified as a certain category of disasters. The 2014 Ebola crisis in Guinea was considered a public health incident in a small community when the first case was identified. Within six months, the Ebola virus spread into neighboring countries, Liberia and Sierra Leone, causing 5,000 cases and 2,500 deaths. Even though great medical support was allocated through international response collaborations, the outbreak extended over a long period of time and became the largest and longest Ebola epidemic. This result was not because of the Ebola virus itself, but because of the amplified effect by the integration of several contextual factors, a 'perfect storm' (Piot, 2014): weak governance system caused by long-term civil wars; chronically marginal economic and social infrastructures; a huge lack of health services with a major scarcity of health workers; and strong traditional social norms including social relationships and funeral practices. The Ebola storm, which was driven by complex synergy among these contextual factors, created an unprecedented crisis. What was first considered a public health outbreak became a full scale humanitarian crisis.

This shift in thinking has major implications for what is needed to stop epidemics. Particularly in under-resourced countries, the medical focused operations, such as treating and

caring for patients and isolating infectious individuals, cannot effectively gain control over the fast-paced epidemic outbreak. Even though response coordinators plan to treat patients in a hospital, such operation plans cannot succeed without supplies and doctors. Depending on the social-economic context, a public health outbreak requires a comprehensive humanitarian operation mobilizing a wide range of resources, such as food and water provisions and household sanitation kits. This wide range of humanitarian operations serves a more critical role than just a medical-focused response in saving more lives.

A key factor to deal effectively with any type of disasters is how to quickly establish an efficient coordination system to identify, procure, allocate, deliver and distribute critical resources to meet current particular needs in a relief logistics network. In general, any disaster-affected area needs to rely substantially on external assistance and resources because the impact of a disaster causes not only human mortality and loss of livelihood, but also a huge loss to the economy (Yadav & Barve, 2015). Under-developing countries are especially reliant on international aid, which requires more complex logistical activities from international to national, county, and community levels. All field operations in affected communities cannot be initiated until adequate and appropriate resources arrive at the communities; meanwhile, the damage from the disaster increase. From this perspective, disaster management and relief aid require complex logistical activities, as the resources they need are rarely available at the location of the disaster.

1.3 International Humanitarian Relief Logistics System

Wassenhove (2006) considers humanitarian relief logistics (HRL) a central point for at least three reasons. First, humanitarian relief logistics serve as a bridge between disaster

preparedness and response and between procurement and distribution. Without this logistical support, any operation plan cannot be realized in the field. Second, HRL determines

the effectiveness and speed of response for major humanitarian operations, such as health, food, shelter, water, and sanitation. Third, HRL is the most expensive part in the entire response operation because logistics accounts for 80% of the entire relief activities. Therefore, HRL should be considered a core factor that differentiates between successful and failed types of relief operations (Cozzolino, Rossi, & Conforti, 2012). This section identifies HRL's roles, tasks, contributions, and challenges in real field operations.

1.3.1 Major function and role of relief logistics cluster

The logistics cluster is responsible for preparedness to procure and manage inventory and for the emergency response to coordinate participating organizations in logistics services. The WFP has played a critical role in leading the logistics cluster in humanitarian crises. The WFP is equipped with advanced expertise and techniques to manage the logistics system and additional transport resources, networking with the United Nations Humanitarian Air Service (UNHAS) and the United Nations Humanitarian Response Depot (UNHAS) (Quinn, 2010). With sufficient human, physical, and technical resources from the WFP, the logistics cluster has direct authority to prioritize cargo with a required transport means. If the field of response operations has a poor or destructed transport infrastructure, then the logistics cluster plays a critical role in enlarging the operational capacity by not only procuring and delivering resources but also providing transportation means to all working clusters.

It is easily assumed that managing the relief logistics is a technical job, only requiring information concerning transport routes and infrastructure status such as the quality of roads, warehousing, and airports. However, the relief logistics cluster needs the full picture of an on-going situation concerning the priority of operational goals, characteristics of critical resources,

major target recipient groups, and other clusters' major tasks within the entire operational plan. Without this comprehensive understanding of the entire operation, the relief logistics cluster cannot develop strategic plans to manage resources efficiently to support the entire operations while meeting particular needs of different clusters in coherence. In the entire operational coordination, the logistics cluster has the responsibility to 1) collect all information in detail from other clusters, 2) plan how to manage resources with required facilities and transport means for the entire operations, 3) share these operational plans with other working clusters, and 4) distribute allocated resources to the right recipient. All these activities need to continue simultaneously until the entire operation is complete. The logistics cluster serves a core function to streamline the entire operational coordination process, which substantially focuses on 1) who has what resources, 2) who needs what, 3) who can deliver what to where, and 4) how those resources are delivered, by enhancing information management and exchange in a timely manner across different working clusters (Jahre & Jensen, 2010).

To get this diverse type of contextual information in a timely manner, the logistics cluster requires close coordination within a cluster, across clusters, and even with national and local authorities (Jahre & Jensen, 2010). For example, a health cluster provides the number of affected patients and health conditions in each community, which is critical information to identify the types of resources and demands of those resources to develop a logistics plan. To know road conditions and availabilities, only local logistics authorities can provide detailed information, which enables the logistics cluster to develop efficient delivery plans. Logistically relevant information should be shared not only for a logistics cluster to serve professional delivery tasks but also for all other participating clusters to have an appropriate understanding of logistical needs and information.

1.3.2 Challenges of humanitarian relief logistics in the field

It is not quite clear how much the relief logistics cluster exercises its leadership when it comes to operational coordination in the field (Cosgrave, Gonçalves, Martyris, Polastro, & Sikumba-Dils, 2007). Unfortunately, in the real field of international operations, logisticians play a limited role in carrying out a decision (Thomas, 2003). The assessment team often does not include logistics experts to develop an operational plan to determine the needs of affected areas. Considered as a technical assisting cluster, the logistics cluster only comes to a field after an international emergency call. When the logistics cluster is set up at the field, the operational plan often delays the entire operation because it lacks core information of a logistics plan and system, and it lacks authority of logistics experts to influence a decision making process (Thomas and Kopczak, 2005). Without a systematic strategic plan and coordination to manage aid resources, which requires support by specialized logistics knowledge, the sheer quantity of donated resources create chaos in response operations due to a shortage of transportation, warehouses, and viable routes. The lack of awareness of significance of the relief logistics function among participating clusters has undermined the effectiveness of the entire operational coordination.

Unfortunately, the logistics cluster needs to bear all the blame for any late arrival of relief supplies even though this late arrival was caused by a failure to establish an effective coordination mechanism adapting to a field (Kaatrud, R Samii, & Van Wassenhove, 2003). The current bifurcated international coordination system between general humanitarian crisis and public health crisis can limit the role of the relief logistics system even more in the future. If there are no clear-cut definitions of a general humanitarian crisis or a public health crisis, then it will take a longer time to assign a global leading organization to take charge of the entire operation. The delay of leadership assignment, in turn, causes a late international call, which

consequently delays the time for the relief logistics system to be set up in the field. After the relief logistics system is set up in the field, participating organizations need to figure out what characteristics of a disaster are interacting with the field environment.

Many scholars have suggested how to categorize disasters according to their characteristics, which guide and determine the goal of the relief logistics system. For example, in a relief logistics system, slow-onset disasters such as a famine require more precise predictions for resource demands of a certain area in the long-term. In contrast, sudden-onset disasters such as earthquakes and tsunamis cause a huge destruction of the region by destroying transportation, electricity, and communication infrastructures (Barabasoglu et al., 2002). In this case, the logistics system should make substantial efforts to plan alternative routes and channels to send resources by diversifying transportation vehicles. However, some disasters have mixed features combining slow-onset and sudden-onset characteristics such as an epidemic outbreak like the Ebola virus, for instance. Due to a long incubation period, the virus spreads slowly in a limited geographical boundary, which can cause the relief logistics to slow down. If affected people move around during unnoticeable incubation periods across borders of communities, new affected cases start to spark here and there simultaneously in an unpredictable way. In this case, planning the relief logistics system solely based on the disaster characteristics could cause unexpected scenarios.

In addition to the disaster's characteristics, it is necessary to take account of institutional characteristics that cause substantial need for logistics when certain institutional factors interact unfavorably with the characteristics of a disaster. A disaster is generally defined among international stakeholders as such:

> "[…] a serious disruption of the functioning of society, posing a significant, widespread threat to human life, health, property or the environment, whether caused by

accident, nature, or human activity, and whether developing suddenly or as a result of complex, long-term processes" (UN/ISDR, 2004, p.3).

This definition implies that if the society has the capacity to deal with the consequences of certain disruptions, those disruptions are not considered as a disaster. Even for the same type of disaster with the same severity, an affected society with more vulnerable social conditions requires greater logistic supports than a society where lots of human and physical resources are prepared. The current relief logistics framework needs to provide guidelines for how to analyze the physical characteristics of potential environmental factors, which increase damage when those factors interact with the characteristics of a disaster.

Another challenge is that major tasks such as providing transportation means in a relief logistics system should be continually modified, depending on the crisis. The current disaster management framework provides how to differentiate relief phases with the relief logistics system's tasks. Minimal distinctions of relief phases are categorized between preparation and post-event phases (Long, 1997; Van Wassenhove, 2006). The ways in which scholars differentiate these phases has overlapped. Some scholars differentiate between emergency relief, rehabilitation, and development (Ludema, 2000). Other scholars differentiate between mitigation, preparedness, response, and recovery (Altay & Green, 2006). And, still, other scholars differentiate between preparation, immediate response, and reconstruction (Kovács & Spens, 2007). As it is now, there is no tangible breakdown in tasks for each phase of disaster operations, because under the current international disaster response framework, the relief logistics system is led by whichever organizations respond.

The relief logistics system and strategies should be able to adapt quickly to the characteristics of a disaster and local environmental conditions in the field. Once the relief logistics system is set up in the field, the coordinators start to design and deploy at once, even though the knowledge of the situation is very limited (Beamon, 2004; Long and Wood, 1995;

Tomasini and van Wassenhove, 2004). In general, the main problems during the response period are caused by the supply management, unpredictability of demand, and last mile distribution of resources to victims (Beamon, 2004; Long, 1997; Long & Wood, 1995; Özdamar & Küçükyazici, 2004; Tomasini & Van Wassenhove, 2004). For example, they may have a map of infrastructure before arriving at the site. However, when they see the real condition of the infrastructure, they don't have inside information about who they need to contact and cooperate to deal with the situation. Even though these problems give a general idea of what the relief logistics system needs to do when the teams arrive in the field, the current framework does not provide detailed context. During a response phase, the damages of a disaster could be effectively minimized or exacerbated within a short time depending on how quickly participating organizations prioritize the urgent needs. The current relief logistics framework needs substantial improvement with detailed guidelines of what environmental and institutional factors should be considered in developing a response plan.

Another challenge that faces operational coordinators is to create a collaboration among different participating organizations (Gyöngyi Kovács & Spens, 2009). As mentioned above, the number of participating organizations and the types of organizations have been growing substantially. Such growth makes an effective collaboration difficult because each organization has not only different expertise and resources, but also different operational manners, goals and interests in participating in a relief logistics system. To create a successful collaboration, the relief logistics system should have an effective coordination mechanism to overcome all these differences among the participating organizations. A critical task for the leadership in a relief logistics system that acknowledges these differences is to determine "which organizations she/he can effectively collaborate with for what purpose" (Kovac and Spens, 2009, p.512). But the mere knowledge of which organizations are present in a site is not always

helpful because finding the ‘right’ partner implies not only what kinds of organizations there are, but also when those organizations are most needed.

Jensen and Hertz (2016) recognized that there are multiple separate coordination mechanisms in field operations because in the early response stage, various types of participating organizations bring their own operational agendas. Also, the number of types of participating organizations keeps changing over an operational period. Some organizations steadily participate in coordination, whereas other organizations inconsistently joined the coordination during the operational period. When added all up, these accumulative inconsistencies highlight how the current framework needs to provide a guideline of how to help participating organizations in the system to create the right partnerships in the system by understanding organizational behavioral mechanisms.

1.4 Current Research Trend

The current relief logistics system under the international cluster coordination approach has faced lots of challenges to increase its performance in response to a crisis. These challenges range from weak leadership of the logistics cluster among participating clusters in a decision-making process to a lack of coordination strategies within the cluster and across the clusters. These challenges highlight the urgent need for research in the relief logistics system and disaster management fields to fill those gaps. Most logistics studies since 1980s have developed as supply chain systems in business contexts as a critical strategy to increase a corporate profit (Harland, 1996; Oliver & Webber, 1982). The engineering approach also contributed to developing a simulation model to manage inventory and delivery schedules in a timely manner with limited interruptions which challenge regular supply chain operations (Ingalls, 1998; Kritchanchail & MacCarthy, 2000). However, humanitarian relief logistics should be

distinguished from business-based and engineering supply chain approaches due to the totally different working contexts. Business-based supply chain and engineering approaches assume that logistics activities are operated based on relatively fixed schedules and predictable demands within the fixed number of interacting organizations. In contrast, the humanitarian relief logistics is operated based on unpredictable demand and supply within the unpredictable number of participating organizations (Kelly, 1995; Kovács & Spens, 2007; OECD, 2004; Ratliff, 2007). Because of these distinctive contextual characteristics, the study of humanitarian relief logistics has recently started to get paid attention by academics and practitioners (Kovács & Spens, 2010).

As a recently developing area, the field of logistics study has neither a unified theory (Mentzer et al., 2004) nor a long history of theoretical accumulation (Stock, 1997). According to Bhamra , Samir Dani & Kevin Burnard's (2011) systematic literature review from 1976 to 2010 which provides the future direction of research to improve resilience from a disaster risk, the research for relief logistics system first appeared in 2004 and accounted for 11% of the entire research papers: nine out of eighty-one papers. The relief logistics theories should be developed and advanced by integrating other scientific disciplines (Stentoft Arlbjørn & Halldorsson, 2002; Stock, 1997)while distinguishing its unique environmental context. The most recent comprehensive systematic review of humanitarian relief logistics management analyzed 87 articles based on 8 classifications. These articles were published between 2007 and 2016 and archived at the academic databases of Scopus and Web of Science (Chiappetta Jabbour et al., 2017). This section summaries the recent research trend reviewed by Chiappetta Jabbour et al (2017).

1.4.1 Research purpose

At the beginning stage of a theory development, many researchers made efforts to identify distinguishing features of humanitarian relief logistics networks from other supply chain networks. There are major five streams of research serving this purpose: logistical coordination, framework development, comparative analysis between classic model of supply chain and relief logistics system, performance measurement, and simulation model. The coordination in the relief logistics network among participating organizations has been considered as the most challenging issue to create collaboration. Investigation of coordination process (Akhtar, Marr, & Garnevska, 2012; Balcik, Beamon, Krejci, Muramatsu, & Ramirez, 2010) and identification of the drivers and barriers of the coordination (Kabra, Ramesh, & Arshinder, 2015; Kabra & Ramesh, 2015) have been the most popular area but still very short of research both in quantity and quality. This coordination-focused research needs more practical strategic suggestions to improve the coordination corresponding to an operational performance changes with diverse analysis methods rather than illustrating cases. The research approach to develop a framework seeks to analyze the cluster system as the current coordination framework in the field and to integrate the current framework with a new theory to propose new avenues for the advanced framework of relief logistics network. The comparative analysis between classic model of supply chain and relief logistics network is to illustrate differences in the decision-making process. Another major stream is to develop the performance measurement of relief logistics network (Beamon, 2004; Whybark, 2007; Harjai & Abraham, 2005; John et al., 2012). One of the major interests in measuring the performance of relief logistics network is to increase the system's resilience defined as the ability to absorb the impacts from an unexpected disruption caused by a disaster and to return to regular operation. Kaur and Singh (2016) have studied relationships between such resilient supply

chains and sustainability outcomes. Recently, few researchers have made efforts to develop and expand mathematical simulation models to plan routes and storage places of inventories under uncertainty (D'Uffizi, Simonetti, Stecca, & Confessore, 2015; Sheu, 2007) and coordination processes (Krejci, 2015).

1.4.2 Type of disasters

Chiappetta Jabbour et al. (2017) categorized the types of disaster as: 1) man-made with slow-onset, 2) man-made with sudden-onset, 3) natural with slow-onset, 4) natural with slow-onset, 5) not applicable. Over 60% of the current research did not focus on the characteristics of disasters, because, as mentioned above, the majority of the current research focuses on developing a general framework applicable for any kind of disasters. The majority of the research (28.7%) focused on operations in response to natural sudden-onset disasters such as earthquakes and tsunamis. The relief logistics network in response to man-made slow-onset disasters, such as a nuclear risk, accounts for 4.5%. The relief logistics network in response to natural disasters with slow-onset, such as the Ebola epidemic diseases, have rarely been researched. This current trend indicates a serious lack of diversity in the research of disaster types. Heavily focusing on sudden-onset disasters, the current trend of research interest only can demonstrate short-term strategic changes and features of relief logistics coordination. The study of relief logistics network needs advanced research which can show dynamic changes of the relief logistics network over a longer period of operations, which will draw more practical suggestions. Furthermore, future research needs in-depth investigation to figure out how environmental contexts in the field influence the prediction of the required characteristics in the relief logistics network.

1.4.3 Research method

Chiappetta Jabbour et al. (2017) categorized the type of methods as 1) qualitative, 2) quantitative, 3) conceptual, 4) modelling, 5) survey, 6) others quantitative approaches, 7) single case study, 8) multiple case study, 9) interviews, 10) others qualitative approaches, and 11) mixed methodology. The majority of research adopts a conceptual approach (26.44%) and qualitative methods (19.05%). In contrast, quantitative (9.52%) or quantitative-qualitative mixed (3.17%) approaches are very few. Because of limited chances to collect data for relief logistics activities during a crisis, researchers could not utilize various methodologies to reveal diverse perspectives of relief logistics activities influencing disaster management. To establish the strong foundation of relief logistics network study, the increase in data availability and access is a crucial challenge to be overcome.

1.4.4 Participating humanitarian organizations and their roles

Chiappetta Jabbour et al. (2017) categorized major participating humanitarian organizations as 1) supranational aid agencies, 2) governmental organization, 3) big international, non-governmental organizations (INGOs), 4) small national, non-governmental organizations, and 5) not applicable. The majority of research (65.62 %) does not target to study certain types of organizations. A few research studies focus on supranational aid agencies (10.34%) and governmental organizations (9.20%). Recently, a research interest in INGOs increased followed by the increasing number and the diversity of response activities operated by INGOs (Grogg, 2016; Atouba & Shumate, 2015). Even though an increasing number of diverse organizations participated in a coordination system of the relief logistics network, only a few types of organizations have been studied at the marginal level.

This narrow interest in only a certain type of organization results in shortage of understanding of strengths and weaknesses of participating organizations to serve a particular role (Jensen & Hertz, 2016). Depending on characteristics of a disaster, required tasks are varied. Since the participation in a relief logistics network in the field is on a voluntary basis, participating organizations keep changing over time. The understanding of participating organizations' strengths and weaknesses plays a critical role in coordinating the participating organizations to efficiently develop operational strategies and assign particular roles and tasks in response to a time critical situation. The currently limited research investigating few types of participating organizations in the relief logistics network only shows a marginal piece without the entire picture of the relief logistics system. The future research should expand its interest to provide a comprehensive framework of relief logistics networks consisting of diverse types of organizations by recognizing their characteristics.

1.5 Summary

The current policy framework, the cluster system, has been criticized with many weaknesses. First, the cluster system does not provide practical advice or suggestions to coordinate the relief logistics network according to different stages of response operations. Concerning that the nature of disaster response situations is dynamic and unpredictable, the coordination manner of the relief logistics network also should be changed dynamically to meet the current needs. However, the cluster system only shows the ideal coordinating features which can be set up only after a dynamic situation is under control. The cluster system cannot deal with real challenges at the beginning stage when lots of participating organizations come to the field and need to set up coordination system of the relief logistics network (Jensen & Hertz, 2016). Therefore, the current coordination framework, the cluster system, has an urgent

need to identify specific tasks which are required to be done and to provide practical coordination strategies according to each stage of disaster response operations.

A lack of coordination across clusters is continuously highlighted as a critical defect in the current system in a field operation. It has been noted that "….there was a general feeling among NGOs that clusters were overly compartmentalized and there was no need for so many" (ActionAid, 2007, p.5). The initial evaluation of the cluster system after two years stated that, "A more fundamental barrier to addressing cross-cutting issues stems from weak inter-cluster coordination, including inadequate information management and analysis" (Stoddard, Harmer, Haver, Salomons, & Wheeler, 2007, p.40). The current policy framework should be developed to be a comprehensive coordination system of the relief logistics network which creates collaboration inside and outside of the cluster system. To create a comprehensive coordination system in the relief logistics network, theoretical research should provide realistic and practical strategies in terms of response phases reflecting changing environments during a disaster while strengthening and extending theoretical foundations.

The importance of inter-organizational collaboration in humanitarian operations has been dramatically highlighted in recent years (Balcik, Beamon, Krejci, Muramatsu, & Ramirez, 2010; Schulz & Blecken, 2010). Even though the relief logistics network is a core part in increasing the success of disaster management systems, it still lacks theoretical development supported by diverse perspectives (Oloruntoba, Hossain, & Wagner, 2016). The current research trend, which is limited to few types of organizations in the cluster system with a qualitative-based exploratory study, cannot provide a holistic and concrete framework to create a comprehensive coordination, leaving a huge gap between theory and practice in the area of disaster management (Coles, Zhang, & Zhuang, 2017).

This shortage of relief logistics network studies in quantity and quality potentially limits the awareness of the substantial contributions of the relief logistics network to the entire

response operations among participating clusters and organizations in the field of a disaster. Furthermore, without substantial research to develop advanced frameworks and theories reflected by a real situation, the performance of the relief logistics network also cannot be improved in the field; a low performance of the relief logistics network, in turn, further lowers other participating organizations' awareness toward the role and contributions of the relief logistics network. These current challenges in the field of relief logistics network studies could create a vicious cycle to undermine the performance of the relief logistics network in the field and awareness of its significance in the entire response operation.

To meet the current urgent needs in the study of the relief logistics network, this research aims to provide a new framework by integrating different theories to show the dynamic changing process of a coordination mechanism. To be specific, this research seeks to provide a comprehensive coordination mechanism of the relief logistics network according to a response stage to create a comprehensive and coherent relief logistics system. To achieve this goal, the following chapter introduces relevant theories to demonstrate 1) interactions between potential environmental factors and characteristics of a disaster to determine the goal and objectives of the relief logistics network, 2) a mechanism of participating organizations in the relief logistics network to find their right partners based on organizational perceptual factors, 3) evolving pathways to create a coherent and efficient logistics network through over-time coordination, and 4) detailed coordination strategies which enhance the performance of the relief logistics network.

2.0 Framework and Theories

In order to understand how systems interact with physical characteristics of surrouding environments and vice versa, it is important to study how open systems handle uncertainty. At the basic level, a system is an integrated whole made of interrelated elements. In an open system, the behavior and performance of those interrelated elements are more easily influenced by the external environment (Ackoff, 1973). On the other hand, a system can also be so integrated into its environment that system and environment become one entity, creating an entirely new environment (Luhmann, 1984). For example, when an unpredicted crisis breaks social regular routines and rules, social elements including individuals and organizations try to adapt to the changed social system by creating new rules. These new rules which adapted to the changed social system generate a new social system. Since the pattern of the inter-relationship between the system and the environment as a whole are neither controllable nor predictable, the open system has to deal with uncertainty (Thompson, 1967). Nevertheless, it is very necessary to identify individual elements and their interactions as much as possible so that people can have a better understanding of the open system and can reduce the level of uncertainty (Katz & Kahn, 1978). Thus, this study pays careful attention to identifying individual elements and to understand not only their individual natures but also their interacting features with the external environment. This understanding will help to optimize decision-making by achieving better control on known elements and interactions and by better adapting to unknown elements.

2.1 Complex Adaptive System Framework

A complex adaptive system (CAS) is defined as a system that emerges over time into a coherent form and adapts and organizes itself without any singular entity deliberately managing or controlling it (Holland, 1995). Rooted from evolutionary biology and non-linear dynamical systems, the current approach of CAS focuses on the interplay between a system and its environment and the co-evolution of both the system and the environment. The way in which a system evolves is dependent on dynamic elements of the networks within a system, where nodes and edges change (Surana, Kumara, Greaves, & Raghavan, 2005). This co-evolution does not occur through a central control or deterministic management. Rather, it is generally understood to be an emergence process that leads to the appearance of structure.

The combination of structure and emergence leads to self-organization defined as "a process in which new structures, patterns, and properties emerge without being externally imposed on the system" (Pathak, Day, Nair, Sawaya, & Kristal, 2007, p.550). The result of the self-organization not only changes the patterns of interactions within the system, but also changes the external environments. Following the state changes of nodes and edges, the topology of the network evolves in time in a nonlinear and heterogeneous manner. These characteristics, which exist in quasi-equilibrium, show a combination of regularity and randomness (Pathak et al., 2007).

To understand how the patterns of behavior of individual agents relate to the emergent dynamics of the networks interacting with surrounding environments, it is helpful to see individual components and understand their roles in CAS. Figure 2 summarizes the CAS structure and its components (Choi, Dooley, & Rungtusanatham, 2001).

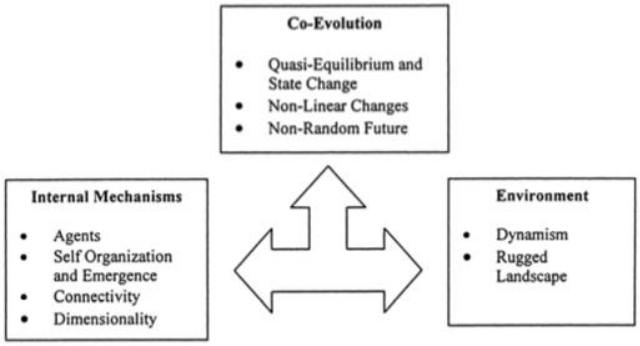


Figure 2 Underlying dynamics involving complex adaptive systems

The CAS is composed of three parts: internal mechanisms, external environment, and co-evolution process. Internal mechanisms are created through connectivity with varying degrees among multiple agents, through which information and resources flow. Agents have their own interpretative and behavioral rules (Argyris & Schön, 1997). These rules are established based on norms, culture, values, and beliefs shared among the collective (Schein, 1997). These agents behave in a manner so as to increase fitness of the system that they belong to either local or global boundary. Due to limited boundaries of connections, the agents often follow the vast majority of collective behavior in a local environment. Meanwhile, in the entire system, behavioral rules occur in simultaneous and parallel non-linear processes. This self-organizing process results in emergence characterized with new and unexpected structures, patterns, and features in the connected network. A self-organizing process over a long-term allows the agents to be connected to a global environment; their behavioral rules are reconfigured to increase their fitness to both local and global environments. This whole process causes the entire network to evolve.

The environment of a given CAS is made up of a very large number of other CASs, each of which keeps changing itself and causes other CASs to change. This environment is changed when one CAS alters the boundaries of the system by including or excluding particular agents and by adding or eliminating connections among agents. This process, in turn, changes the underlying patterns of interactions in the system. The environmental changes require new rules

and norms as the fitness standard is also changed. An optimal performance of a CAS within a certain local boundary might not achieve a global optimal performance. Even if system components are optimized individually, the integrated results contributed by those individual components might not meet an optimal state in the system. Since the value and state of those components are tightly coupled (Kauffman, 1996), it is very hard to predict what kinds of integrated collective results will be driven by the interactions of those individual components.

When a CAS is triggered by other CASs' changes, a CAS will keep changing, and eventually the collective environment changes, too. However, it does not mean that the CAS changes without limits. The systems "compete or cooperate and utilize the same limited resources" (Goldstein, in Zimmerman, Lindberg, & Plsek, 1998, p.263). These interactions among the systems create feedback mechanisms in that the environment forces change in the entities that reside within it, which, in turn induce changes in the environment. Through creating and reacting to feedback, a CAS moves to and maintains a quasi-equilibrium state, balancing between complete order and incomplete disorder (Goldstein, 1994). This quasi-equilibrium state, which is called "edge of chaos" (Kauffman, 1993; Lewin, 1999), allows the system to maintain order while also enabling it to react to qualitative changes in the environment. However, these qualitative changes of behaviors and rules in the system do not result in the same amount of system change because the complex interaction of many loosely coupled elements creates non-linear phenomena. Large changes in input may lead to little changes in output, or vice versa (Guastello, 1995). Nevertheless, the patterns of CAS changes are neither unpredictable, untraceable, nor random. Rather, the system exhibits an archetypal and prototypical behavioral pattern in their changes. The CAS study aims to explore and understand the laws and mechanism by which complicated, coherent global behavior can emerge from the collective activities of relatively simple, locally interacting components.

2.2 Relief Logistics Network as a Complex Adaptive System

The major goal of relief logistics network is to transfer resources, encompassing a range of activities, including preparedness, planning, procurement, transport, warehousing, tracking and tracing, and customs clearance (Thomas & Kopczak, 2005). These multiple activities are performed by different organizations, and their performances are inter-related with one another. The relief logistic activities are connected through not only linear chains of one-to-one business relationships but also a web network of multiple organizations. Because the performances of these activities are closely inter-related, the exchange of resources is the manifestation of how information flows from one organization to another and through the web. Thus, the flow of information in the relief logistics network determines how effectively the flow of resources among participating organizations supports the diverse activities, which allows the resources to reach the final recipients (Surana et al., 2005).

The relief logistics network is characterized as a complex system, rather than a linear process, connected through a very large number of interactions and interdependencies among different organizations' processes, information, and resources. This nonlinear nature of the relief logistics network shows complex multi-scale behaviors. The relief logistics are coupled networks (Jahre, Jensen, & Listou, 2009) across international, national, county, and local levels. In relief logistics, international organizations or donor organizations first collect the resources, and those resources are allocated to certain recipient countries according to their urgencies. Those allocated resources are then transmitted through logistics services that bridge international and national levels, national and county levels, and county and community levels. In addition, each level of the logistics network consists of diverse roles of organizations, including donor, coordinator, logistics service, communication support, and field operator. Because the comprehensive system joins with relief logistics networks across multiple

operating levels, the performance of one level of relief logistics influences the performances of subsequent levels (Kovács & Spens, 2008; Schiffling, 2013).

The relief logistics network is an emerging system reacting to the external environment by creating an internal environment where organizations look for complementary partners. How the external environments interact with the characteristics of a particular crisis shapes the challenges of the relief logistics network. When the participating organizations face unexpected working constraints in unfamiliar operational fields, they need to figure out new strategies to stabilize and optimize their performance. To overcome such challenges, they strategically find partners who have complementary capacities to overcome those particular challenges. Since the environment keeps changing, individual strategies and partners also keep changing. Without an understanding of the characteristics of the working environment and its changes, organizational self-adapting processes in the relief logistic network cannot be fully explained.

This continuous self-adapting process through strategy changes of each organization, in turn, reconfigures the entire structure of the relief logistics network in response to internal and external disturbances. Whenever the environment is changed, the relief logistics network, as a whole, needs new or modified directions to deal with emerging problems with new solutions. However, those participating organizations that autonomously work with different objectives perceive the situation based on their own schema without knowing the totality so that they make a localized decision. Due to these complex attributes, the relief logistics network needs to face recurring challenges that cannot simply be ‘solved’ once and for all. Organizational limitations in perceptions in a continuously changing environment can cause challenges of how to define a problem and identify solutions. Every small strategy change can undergo a radical structural change when they are stretched from equilibrium. At such a point, a small event can trigger a cascade of changes that eventually can lead to a system-wide reconfiguration.

This system-wide reconfiguration, in turn, substantially influences individual organizations' welfare and performance, because it can create a new challenge in a local environment of participating organizations. For example, if one international donor organization had access to an international airline to send resources into the field, it wouldn't help any if there was not enough national storage for the resources it sent. Featured as nonlinear interactions and strong interdependencies among participating organizations, the relief logistics network needs emerging orders and controls, which are opposed to pre-determined rules (Surana et al., 2005).

A coordination process among participating organizations plays a critical role in creating new orders and rules shared by the participating organizations in the network. When participating organizations come together, they come with their local information and resources. The collected information enlarges individual organizational schema to perceive the environment, which redirects their operational goal and strategies. Also, this coordination process provides all participating organizations with greater opportunities to find the right partners who fit better to the enlarged understanding of the environment. The emerging order and rules developed through the coordination process help the participating organizations to make the right decision not only for themselves but also for the entire network. Effective coordination plays a key role in increasing network performance by guiding the participating organizations to achieve the optimal local performance out of which a global order emerges.

This coordination process has been pointed out as a 'wicked problem' (Tatham & Houghton, 2011). The large numbers of diverse organizations that have inconsistent participating motivation and different ways of working also compete with one another for the same pool of resources. Even though the coordination process generates a new rule to adapt to a new changing environment, each organization utilizes those rules to increase its own interest rather than collective good. Those rules will ultimately create other unpredictable challenges

in the relief logistics network, decreasing the network performance. Therefore, the coordination needs specific protocols to arbitrate resource conflicts among the participating organizations.

Another problem in coordination is caused when the coordination sets a wrong or unmatched rule to a changing environment. This problem is created when information is limited in coordination. If the participating organizations in the network share the similar schema to perceive the environment, then their diagnosis of the problem would miss some critical perspectives in a changing situation. As a result, new rules established based on their problem diagnosis would fail the real needs of the new situation, which fails the entire system. Working in a time critical situation, the relief logistics network urgently requires having a clear but realistic coordination mechanism to design and reach a global optimal goal while keeping a quasi-equilibrium state.

2.3 Subsidiary Frameworks and Theories

"A central goal of the sciences of complex systems is to understand the laws and mechanisms by which complicated, coherent global behaviors can emerge from the collective activities of relatively, simple, locally interacting components" (Choi et al., 2001). To address inter-dependent complex challenges to effectively implement a relief logistic network, the following section decomposes this complex system into several subsets and re-defines their interactions as whole by applying Choi et al.'s complex adaptive system (see Figure 2). Relevant subsidiary theories aid characteristics of each substance and the interpreting behaviors and dynamics among those substances in a relief logistic network. These theories help to define specific questions which highlight particular perspectives embraced by the main research question.

2.3.1 The environment: Institutional analysis development and framework (IADF)

As pointed out in Chapter 1, the goals and objectives of the relief logistics network are substantially determined by the result of interactions between potential environmental factors and characteristics of a disaster. Understanding institutions is very important to optimize decision-making within given conditions; it leads to a better control of known variables and interactions and more effective adaptation to unknown elements (Ostrom, 1990). Society as a system consists of multi-tier subsystems. Those subsystems are interconnected and nested in the higher level of institutions. Institutions play a fundamental role in explaining one's decision, given the following reasons: first, institutions provide 'rules of the game' that serve as criteria for decision making; second, these rules justify and explain the actions taken in a particular situation; third, rules can be a part of an individual's habit as the individual becomes more familiar with the rules of action; fourth, rules also serve as prescriptions to organize all forms of repetitive and structured actions.

The consequence of a disaster is a result of interactions between characteristics of a disaster and a field environment consisting of formal and informal institutions. While formal institutions denote regulations, instructions, precepts, and principles, informal institutions denote culture, social norms, and traditions. These rules can be thought of as the set of instructions for creating an action situation in a particular environment (Ostrom, 2009). The same type of disaster with the same severity results in different consequences, depending on institutional conditions of affected areas. The research of humanitarian relief logistics coordination also needs to be contextualized based on a working environment constituted with different rules because a different environment requires different types of relief logistics systems (Charles, Lauras, & Van Wassenhove, 2010; Oloruntoba & Richard Gray, 2006; Scholten, Scott, & Fynes, 2010; Van Wassenhove, 2006) .

This research focuses on the generic characteristics of a disaster itself and institutional factors, which significantly help to identify the required type of coordination of the relief logistics network (L'Hermitte, Bowles, & Tatham, 2013). A disaster is characterized with two dimensions: time and space. The time dimension indicates the time available to take action. One-shot emergency disasters require a logistics system to support immediate assistance and distribution of relief supplies to the victims. In contrast, protracted disasters require a long-term response plan and relief logistics system to distribute different types of relief items according to the progress of a disaster. The space dimension indicates the geographical scope of the affected area. A disaster can be localized or spread over a wide area. A widespread disaster zone leads to a more complex logistics management due to longer travel distances, greater uncertainty of the transport demands, and a heterogeneous distribution network (Holguín-Veras, Jaller, & Wachtendorf, 2012).

There are five critical institutional factors to be considered in the context of coordination in a humanitarian relief logistics network: 1) the governmental situation, 2) the socio-economic situation, 3) the infrastructure situation, 4) the environmental situation (L'Hermitte et al., 2013) and 5) social cultures and norms (Yeo, Li, Shin, & Haupt, 2018). The governmental situational factors include formal authority to accelerate or delay the delivery of relief items, such as customs clearance and importing duties. The socio-economic situational factors indicate the availability of necessary relief items in the affected country and the capacity of local transport and distribution networks (Holguín-Veras, Jaller, Van Wassenhove, Pérez, & Wachtendorf, 2012). The infrastructure condition substantially influences the effectiveness and efficiency of the logistics delivery. If the affected country lacks physical transportation infrastructure, the logistics organizations then need to spend additional funds to find alternative transportation means and routes to reach the victims. The environmental situational factors also contribute to the number and scope of challenges in logistics delivery to access the affected

population. In particular, when a disaster occurs in isolated or remote areas, it costs more to reach the people. Disasters taking place in a community with a higher density of poor households also make the situation a more formidable one. Those with poor conditions are more vulnerable to disease; therefore, an epidemic could infect multiple neighborhoods, thereby requiring more relief items as well as health treatments for the logistics staff. Social cultures and norms generate social behavioral patterns, which can create challenges in a distribution process of relief items while increasing the consequences of a disaster in the affected areas.

These theories center the first specific research question:

"In a disaster, how do the characteristics of institutions and the characteristics of a disaster interact to create unique environmental challenges for a relief logistics system to overcome?"

2.3.2 Internal mechanism: Communal adaptation strategy to solve the collective action dilemma

Individual organizational strategy creates a voluntary mechanism at an organizational level. This adaptation occurs in response to both the "task environment" and the "general environment" (Dill, 1958). The task environment consists of relevant stakeholders such as competitive organizations, final recipients, and partner organizations that directly collaborate to support its regular and ordinary operations. The general environment indicates domains where potential organizations, not current focal organizations, could appear in the future. Since the general environment is an unknown situation beyond the current domain, this is only prepared by the organizations' strategic plan for how to relocate current participating organizations to fit potential niches. However, the task and general environments interact with one another and are inter-related especially when an unexpected external shock breaks the

stability of the current task environment. Individual organizations find it difficult to figure out a viable option to take and adjust themselves immediately into a changed environment because the existing and changed environments are richly interconnected and inter-dependent. Newly emergent focal organizations also might not clearly understand the existence of such interrelations, which could cause potential ramifications in the environment (Emery & Trist, 1965).

Organizations that face the same problem create collaborative networks to increase their capacity to solve the common problems effectively and efficiently. These participating organizations make efforts to create or discover solutions within a given set of constraints, including knowledge, time, resources, and even competition (Agranoff & McGuire, 2003). This collaborative network created by voluntary mechanisms offers several potential advantages over formal decision-making structure. This network can exercise a higher discretion to deal with the problem by creating new rules or modifying existing rules in response to a certain situation through the common agreement among the participating organizations. In this rule-creating and -modifying process, the participating organizations try to collaborate to achieve the common goal while trying to keep their own authorities and to achieve their organizational goals through negotiation. These collaborative networks serve a significant role in finding better policies or improving policy outcomes by mitigating collective action problems as well as capturing a greater advantage from collaborative problem solving (Agranoff & McGuire, 2003; Lubell, Schneider, Scholz, Mete, & Schneider, 2016; Keith G. Provan & Milward, 2001).

To create collective action, the participating organizations need to pay careful attention to reach the common agreement because the participating organizations have asymmetrical information about one another. Those organizations need to deal with transaction costs, which includes information search, and enforcement cost and risk (Feiock, 2009; Gerber, Henry, &

Lubell, 2013; Maser, 1998). The participating organizations are not willing to participate in collective action unless a benefit from the action is higher than those costs and risks. In other words, collective action is expected to arise when potential benefits exceed the transaction costs of negotiating, monitoring, and enforcing an agreement. Three main factors can challenge the organizational collective actions: 1) the participating organizations' opportunistic free-riding behaviors; 2) uncertainty about other organizations' trustworthiness; and 3) uneven distribution of costs and benefits over time (Feiock, Steinacker, & Park, 2009).

In response to a new emergent and unstable environment, a set of organizations collaborate in order to create a collective strategy, which is analogous to communal adaptation (Fombrun & Astley, 1983). Communal adaptation occurs when a specific form of organization is adopted across individual organizations. One type of communal adaptation arises between similar types of organizations. The organizations that share the same attributes or the same membership in a certain category have similar demands on their environment. This type of communal adaptation is to create a relationship of "commensalism"(Hawley, 1950, p.39). In the early communal adaptation stage, this relationship shows a cooperative interaction. When there is a common enemy or challenge, they create a collective effort to deal with the enemy and to overcome the challenge by sharing the same goal. However, in a longer term, this relationship can turn into a competitive interaction, because they are "eating from the same table" (Hawley, 1950, p.39). Another type of communal adaptation arises between dissimilar types of organizations. Because they have dissimilar demands on the environment, different types of organizations may supplement the efforts of one another and thus become mutually interdependent. This relationship can be very indirect.

The relief logistics coordination network exists in greatly uncertain situations with unpredictability of changing environments and the least amount of information about the participating organizations in a network. Because the situation keeps changing in an

unpredictable way, the participating organizations in a network predict neither what kinds of tasks they would serve for how long nor what kinds of organizations would join or exit the network in the next month. The participating organizations need to take a higher risk to find appropriate partners than in a relatively stable environment. This research focuses on the function of similarities within organizational attributes to create organizational partnerships as a strategic action to adapt to changing environments while minimizing transaction costs in the network. Furthermore, concerning rapidly changing situations over a long period, this research argues that the effectiveness of different organizational attributes in creating a partnership will change over time.

These theories center the second specific research question:

"What kinds of organizational similarities play a significant role in creating a partnership to enhance individual and communal adaptations to changing environments in a relief logistics network?"

2.3.3 Co-evolution: Evolution of network structural features

In a relief logistics network as a CAS system, an adaptation process of individual organizations simultaneously occurs, which restructures the entire network through changes of direct and indirect connections linking organizations. While a relief logistics network supports nation-wide operations, individual organizations work in a limited boundary of locations. The organizational partnerships could be made by limited knowledge and information in their surrounding situations. To be specific, an organizational strategic choice for partners would not guarantee to create a benefit to the entire network as whole. If their strategies would not give benefits to a collective level for the long-term, those organizations would fail to adopt or survive in a collective group level where whole participating organizations interact with one another surrounded by a certain environment. The analysis to investigate a collective action

and its changes as whole should include a network structure in addition to an individual strategic action.

A relief logistic network should evolve to increase the efficiency of information and resource transmissions among diverse participating organizations across different operation levels. Working under continuous environmental changes, a relief logistic network faces several unexpected disruptions which destroy regular and normal functions. In response to these dynamics, complexity, and uncertainties, a relief logistic network also should be resilient enough to deal with potential difficulties. The resilience in a relief logistics network is defined as a manner to reduce the severity and consequences of disruptions affecting the performance of a relief logistics network (Boin, Kelle, & Whybark, 2010; Lodree & Taskin, 2008; Mari & Lee, 2012; Ratick, Meacham, & Aoyama, 2008; Tomlin, 2006). The evolving mechanism of a relief logistics network seeks to establish the network structure which efficiently enhances the transmissions of timely information and resources among participating organizations while quickly bouncing back from unexpected disruptions.

Previous empirical research into other real-world networks, including social (Wang, Tang, Guo, & Xiu, 2006), business (Souma, Fujiwara, & Aoyama, 2003), ecological (Solé & Montoya, 2001), biological (Podani et al., 2001) and communication (Albert, Jeong, & Barabási, 1999) systems, reveals the universal network properties derived from self-organizing processes. The final properties reached by nodes (Barabási, 2005; Ramasco, Dorogovtsev, & Pastor-Satorras, 2004) to create the efficient structure of the network are short paths among nodes (Mari, Lee, Memon, & Park, 2015). When the number of nodes increases, the average shortest-path also increases. This short-path feature of a network is also very important to increase the efficiency in a relief logistics network where rapid information and resource distributions determine the entire performance. However, in the real world of networks, few nodes get a major proportion of the entire connections, whereas the majority of nodes get few

connections with other nodes. This feature is also well represented in a relief logistics network where few coordinating organizations take the major proportions of organizational interactions in the entire network. However, participating organizations in the network should have quick access to concentrated important information and resources directly or indirectly even if the size of the network increases with more participating organizations. How to distribute concentrated information and resources efficiently from these few organizations to surrounding organizations is a major issue in creating an efficient relief logistics network.

Resilience of a relief logistics network plays a key role in continuing information and resource supports to the entire operation even with unexpected disturbances. The resilience in a disaster management context is defined as "the capacity to adopt the existing resources and skills to new situations and operating conditions" (Comfort, 1999, p.21). Individual organizations try to enhance its resilience in response to an unexpected situation by creating multiple partnerships with other organizations that can support complimentary resources and capacities. As their partnerships overlap with one another, they are formed as a cluster in the network. Resilience at a network level enables the entire system to continue regular operations even if one cluster of participating organizations could not function well because of external turbulence. To be specific, a resilient network has multiple overlapping clusters of organizations that serve similar tasks so they can replace one another when a certain cluster of organizations could not serve their collective role. The resilient network is featured by high overlaps among smaller clusters within the network (Uzzi & Spiro, 2005).

These theories center the third specific research question:

" How do individual organizational choices of partnerships in a relief logistic network evolve to increase efficiency and resilience of the network in a collective way?"

2.3.4 System adaptation: Theory of fields

The self-organizing evolutions of individual and collective strategic actions in a relief logistics network aims at establishing an efficient and resilient system adapting to a changing environment, so that the collective action can successfully achieve the system goal.

The theory of fields focuses on demonstrating the procedural mechanism of complex and dynamic collective action: how and why a collective action emerges in the first place and how it continuously changes with the changes of surrounding situations (Abolafia, 2005; Fligstein & McAdam, 2012, 2011). The fundamental unit of collective action in this theory is a 'strategic action field,' defined as:

> a "socially constructed meso-level social order in which social actors (either individual or collective) interact with knowledge and resources of one another on the basis of shared understanding about the purpose of the field, with the relationship to others in the field, and with the rules governing legitimate action in the field" (Fligstein & McAdam, 2011, p.11-12).

The theory of fields pays attention to not only a single relationship, but also to integrated relationships among actors and surrounding environments—micro-situations, macro-contexts, and inter-field relationships—which affect emergence, stability and change in a strategic action field (Fligstein & McAdam, 2012, 2011).

A complex system has several peaks of the system performance, illustrated as different peaks of "goodness" or fitness in a certain "landscape". A strategic action field plays a critical role of a central realm where participating organizations effectively identify and reach to the highest performance peak within its surrounding environment. Even though organizations consider that their collective performance reaches to the highest optimal peak, that peak might not be the highest peak of its "rugged landscape" as a whole (Page, 2010). This phenomenon

occurs often when individual or smaller groups of organizations are optimized individually as separate and isolated entities without regard to the entire system. This lack of consideration makes them perceive the global landscape as a single-peaked picture with the single best solution. The real landscape of the system where multiple components interact both in an independently but closely coupled manner has many local optima. In addition, this rugged landscape keeps changing, becoming a "dancing landscape", accordingly with dynamic changes of all components, which makes the participating organizations harder to find the highest optimal peak (Page, 2010). This uncertain change in a strategic action field forces the organizations to find a new strategy that can effectively identify the globally highest optimal peak while keeping the stability of the field.

2.3.4.1 Mechanism of system adaptation: Coordination

Coordination in a relief logistic network plays a critical role in figuring out the optimal peak in the entire operational system, while searching and engaging appropriate resources to achieve the optimal goal. The success of coordination relies on the degree of involvement of the indispensable resources and the actors who own these resources (Scharpf, 2018). Matching organizational capacities to environmental demands is crucial in a relief operation (Fombrun & Astley, 1983). Meanwhile, a relief logistics network needs to quickly adjust vertically and horizontally among the participating organizations to establish an optimal format of network so that these matched organizational functions can be effectively delivered. Successful coordination serves to quicken time for participating organizations to adapt optimally both at individual and network levels.

Successful system adaptation of the entire relief logistics network depends heavily on the timely availability of core information— the clarification of the on-going situation, critical resources in need, and their availability— shared by all participating organizations. However,

each organization's landscape is not homogeneous or simple. The shared information has to address the various stakeholder levels of the emergency. Due to differences in information structure and local contexts where each participating organizations are located (Comfort, Ko, & Zagorecki, 2004), these participating organizations may perceive a situation differently (Hale, Dulek, & Hale, 2005). Such differences lead to conflicting profiles of risk among the participating organizations that, in turn, inhibit coordinated action and collective response. Successful collective action can be achieved when participating organizations develop and share the common picture of the operations system by narrowing individual perceptive gaps.

A coordination process serves as a domain of collective learning process where participating organizations share mental models (Schön & Argyris, 1996; Stata, 1980). Coordination aims to enhance communal adaptations of individual organizations into a collectivity with some degree of individual organizational strategies by changing a rule reflecting a new environment in a system (Fombrun & Astley, 1983). By engaging diverse participating organizations, the coordination process creates organizational communal learning opportunities through ongoing dialogue among participating organizations. A communal learning process taken place through collective experiences and communication helps groups to revise and retain their mental models that determine strategies for decision making (Ostrom, 2009). Even though multiple groups find deficiencies in shared experiences, culture, or ineffective communication, they are able to create collective action by establishing new institutions through a communal learning process. These new institutions re-shape their mental models to understand situations so that they can create collective action by sharing the common picture with a clear goal (North, 2005). Based upon the new rules, individual organizational operations are modified as interdependent disaster organizations working together with their dynamic environments (Comfort, 1993; Comfort & Kapucu, 2006).

This organizational collective learning process should continue because the internal and external environment of the network keeps changing. To follow situational changes and minimize the uncertainty for the course of a disaster, it is necessary to increase the range, frequency, and access to information sources, as well as feedback from the different constituencies exposed to different levels of threat. This dynamic process of information exchange allows reciprocal adaptation among participants as they learn the limitations and strengths of their fellow organizations engaged in the set of shared tasks (Comfort & Haase, 2006). The way that information is continuously processed in a system – how the systems obtain information, how they incorporate that information within surrounding contexts, and how they make decisions to determine how they behave— enables the response system to adapt to a changed general environment by creating a clear common picture of operations and specifying required tasks in detail (Lloyd & Slotine, 1996).

2.3.4.2 Coordination strategy 1: Exploitation Vs. Exploration

To enhance collective learning, major coordinating organizations play an essential role in designing how to develop the learning process. The major coordinating organizations need to decide where to get information to strengthen the operation system in response to a new situation. One strategy is to leverage existing knowledge, skills and capacities. The coordinating organizations utilize known solutions or emulate solutions with whom he or she has a connection: exploitation. In contrast, these coordinating organizations can enlarge the boundary of knowledge pools to find and develop a novel solution. Empathizing the acquisition of external new knowledge, the coordinating organizations look for and create new connections with organizations that have different knowledge, skills and even perceptions: exploration. Especially if a group of focal organizations is composed with similar types of organizations in terms of organizational attributions, this group shares limited perspectives to see a real problem

due to similar mental schema. In a new challenging environment, an explorative strategy plays a significant role in causing the coordinating organizations to seek the highest optimal peak by drawing new logic in the strategic field.

The engagement of new actors into a strategic action field re-arranges the existing logics that operate the system (McAdam & Scott, 2005). While some incumbent groups leave the action field, a new set of actors from the proximate fields take an important position and proposing alternative actions to reach a consensus among other actors. This process slowly re-constructs and develop a new strategic action field (Fligstein & McAdam, 2011). To be specific, changing actors in a strategic action field indicates that the field accepts a new logic and ideas to identify the current problems of the system. When a new set of actors join the field, they bring not only their physical resources or information but also their mental models which identify and define the problems.

This dynamic idea and strategic changes in the action field are observed by boundary changes of the action field. Through newly connected organizations, the action fields could be expanded by reaching out and being connected with other proximate or distant state fields which are also connected horizontally or vertically with further proximate or distant fields. Also, the boundaries of the fields are narrowed when they disconnect ties with organizations located in other fields. This merging process of the action fields illustrates the emergence, transformation, or settlement of a collective action system. In fact, the expansion of the boundaries of action fields by connecting with surrounding fields creates a wider opportunity to obtain new ideas, resources, and practical skills. Those new ideas, resources and skills affect the structure of the strategic action field and could help to strengthen the current stability of the field. Those new sources also could rupture and re-arrange the current structure of the field. Because those changes work as an exogenous shock in the field, actors need to create new logic and rules to re-arrange the field to achieve their goals.

The field boundaries of the relief logistic network are expanded by including new organizations that can provide new types of information. Newly obtained information enlarges collective understanding of the environment. An absence of certain key organizations in response to a particular situation causes the absence of core information in the whole network. A formal coordination system usually appoints a strategic center to coordinate other actors in a collaborative network. In contrast, stakeholder salience depends on the context: specific situations and/or particular issues (Phillips, Freeman, & Wicks, 2003). Those organizations that have more power than the official strategic center in terms of timely critical information and resource, organizational legitimacy, and know-how would be the ones to coordinate and mediate in a real situation. When the major issues of the network change, the strategic center should also change. In other words, stakeholder salience in a collaboration network represents important issues that develop during a certain time period. Accordingly, the pattern of interaction among participating organizations is not permanent. Those organizations find new partners to adapt to the new environment when a central issue in a network is reframed (Rein & Schon, 1993) or when the coordinating rules are changed. Because these changes introduce new types of organizations, the pattern of the networks could be radically transformed (Klijn & Koppenjan, 2000).

2.3.4.3 Coordination strategy 2: Social skills as communication strategies

Social skills of the major coordinating organizations function as a critical capacity to enhance collective learning process. The theory of fields highlights social skills as a key strategy for the current focal actors and new emergent actors to keep or take a dominant position over the action field in situational changes. Social skills indicate empathetic communication capacities which help diverse actors to identify and share a collective set of meanings so that this shared meaning drives collective action by engaging those diverse actors

(Fligstein & McAdam, 2011; Jasper, 2004, 2008). As a situational factor, the macro-contextual conditions, which are mostly external shocks, affect the internal process of transformations of a strategic action field. As a whole, the inter-field relations—the level of dependency within the field consisting of micro situations and macro context—play a most prominent role in directing procedural complexity and dynamics of collective action systems (Fligstein & McAdam, 2012, 2011).

When the boundary of the action field is expanded by including new types of organizations, different sets of actors try to reframe the current problem and direction for the system to move by exercising their communication strategies. Since a new set of actors brings a new logic and mental schema, which sometimes conflicts with the current prevalent mental schema, into the action field, the collaboration between old and new participating organizations creates a 'general sense of chaos' (McAdam & Scott, 2005). To generate new rules in the field, these two groups of organizations need to reach a consensus for "how and what participants value, what resources, information, and beliefs they have, what their information-processing capabilities are; and what internal mechanisms they use to decide upon strategies" (Ostrom, 2011, p.13).

Social skills broadly represent a communication process to illustrate how participating actors who have a highly developed cognitive capacity interpret other and surrounding environments, frame action rules, and mobilize other actors in a way for them to fit to the big picture of the world (Fligstein, 2001; Jasper, 2004, 2008; Snow & Benford, 1988; Snow, Rochford, & Worden, 1986). Social skills encompass the cognitive, empathetic, and communicative capacities. Major coordinating organizations should exercise different social skills depending on the situation in the action field. In stable and well-structured conditions of the system, those coordinating organizations should focus on keeping a status quo. In the emerging conditions which break the stability of the system, they need to take an initiative to

re-configure the action field by helping to create links between existing and new organizations in the action field. To mobilize collective action among different groups of organizations, the major coordinating organizations utilize whatever perspective other groups of organizations have and create an intersubjective shared meaning in the action fields (Fligstein, 2001). This shared meaning enables different groups of organizations to be released from a narrowly shaped view and to take proactive action to achieve the common goal reflecting a wider and comprehensive view of the entire system (Mead, 1934). This signifies the role of social skills as communication strategies particularly in unstable and unorganized situations in the action field, which causes a system evolution.

The relief logistics network composed of different groups of organizations across international, national, county and community operational levels always face a changing environment. As a focal group of a relief logistic network, a group of coordinating organizations plays a central role in setting the strategic action field of the network, collecting information to diagnose the current situation, setting an operational goal, and developing particular strategies to achieve the goal. This processed information substantially leads the entire system to evolve toward a certain direction. Because the participating organizations in the network observe what activities neighboring organizations adopted, not how successfully those activities were achieved, one's adoption sends a signal to other neighboring organizations that they should adopt. This information cascade tendency creates a self-reinforcing process in the system (Banerjee, 1992; Bikhchandani, Hirshleifer, & Welch, 1992).

The information cascade tendency implies three sharp edges in the relief logistics network depending on the levels of social skills in a group of coordinating organizations: 1) immediate recognition of situational changes and needs, 2) establishment of a strategic action field at the right operational level, 3) extensive inclusion of the organizations that can bring new critical information and resources, and 4) effective communication strategies to mobilize collective

action among different groups of participating organizations by creating and sharing the common vision in response to an emerging situation. If any perspective is missing in social skills of a group of coordinating organizations, the entire system would be stagnant, ignorant and broken down into separate pieces of self-focused groups. The level of social skill in the coordinating organizations in the relief logistics is a critical standard to assess the potential of the system's successful evolution. The success or failure of the system adaptation led by a coordination process should be measured by the changing number of affected cases.

These theories center the fourth specific research question:

" How does a group of coordinating organizations in a relief logistics network change their social skills and strategies in leading system evolution successfully in a changing environment?"

2.4 Summary

To address the research questions, this section introduces a critical framework and subsidiary theories by analyzing a relief logistics network and its coordination process to enhance system performance to meet emerging needs. The complex adaptive system framework reflects a dynamic situation where a relief logistics network is operating. A relief logistics network is composed of a number of diverse organizations that serve different tasks throughout multiple operation levels, which creates complexity of internal operating environments. Those diverse organizations need to adapt to one another to create an effective collective action internally, while the organizations both individually and collectively need to figure out how to fit to an external environment. The external environment, composed of formal and informal institutions, exerts a different impact on the performance of a relief logistics network depending on interactions between those institutions and characteristics of a crisis.

Furthermore, because both the external and internal environments of the relief logistics network keep changing over time, the operative manners of the network also should keep changing to fit the environment. These adaptation processes simultaneously proceed in parallel in a relief logistics network. It is addressed in detail in chapter 4.

To address the first question concerning the characteristics of external environments which can significantly influence the performance of a relief logistic network, this research applies institutional analysis and framework (Ostrom, 2005). The institutional analysis and framework is used to analyze fixed conditions of formal and informal institutions and interactions between those institutions and the characteristics of a crisis over time. To address the second question concerning an individual organizational adaptation perspective in a relief logistic network, this research applies a theory of communal adaptation strategy for individual participating organizations to solve the collective action dilemma (Feiock, 2009; Gerber, Henry, & Lubell, 2013; Maser, 1998; Fombrun & Astley, 1983). The fundamental assumptions of this internal mechanism are 1) individual participating organizations will utilize organizational attributes as standards to find trust-worthy partner organizations to improve a mutual performance and 2) the impact of the types of organizational attributes will be changed to create a partnership as an operation time is changed. It is addressed in chapter 5.

To address the third question concerning a collective adaptation perspective as a network, this research applies an evolution mode of network structural features (Barabasi, 2009; Ramasco et al., 2004). The fundamental assumption of a network evolution mechanism is that individual organizational choices of partners do not necessarily increase collective performance as a network in terms of efficiency and resiliency. Chapter 6 presents how the evolution paths of the network features were directed over time in terms of network efficiency and resilience.

To address the fourth question concerning a system adaptation perspective, this research applies the theory of fields (Fligstein and McAdam, 2012). This theory illustrates how the system can improve its performance through a group of focal organizations that exercise widespread influence through its social skills in coordination processes. Following the evolving pathways of the relief logistic network over time, this theory provides the basis to demonstrate the qualitative changes of the coordination processes corresponding to the system performance. Chapter 7 addresses how the quality changes of coordination processes improved or undermined the performance of collective action to meet emerging needs. Particularly, this chapter identifies major threshold points of increasing the system performance corresponding with specific coordination strategies and social skills of major coordinating organizations.

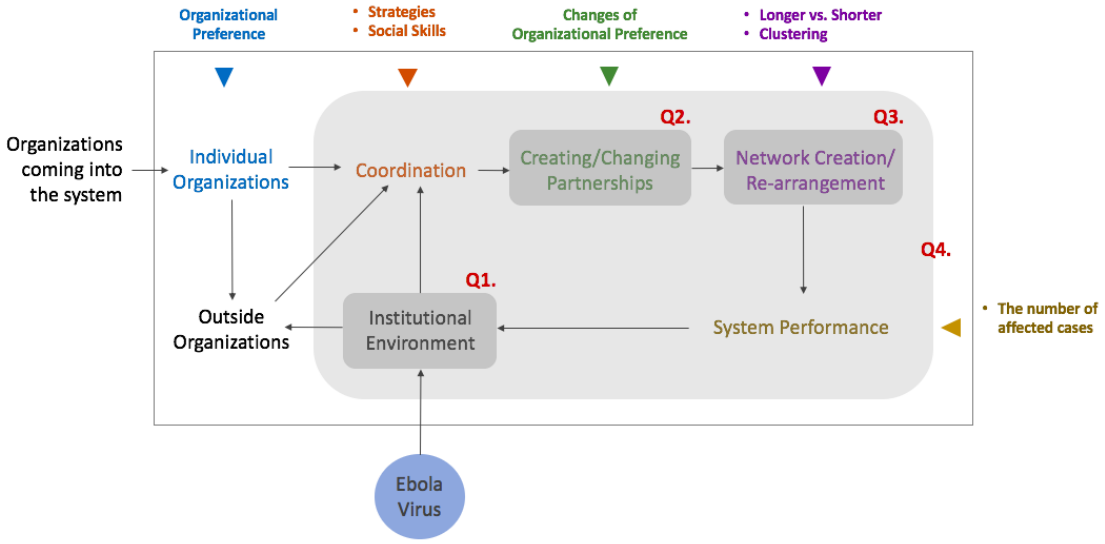


Figure 3 Framework and Research Questions

3.0 Research Design and Methodologies

This chapter introduces how the theoretical concepts reviewed in chapter 2 are applied to address the research questions. Even though the reviewed theoretical approaches in chapter 2 have been individually used to explain social phenomena, there is a lack of effort to integrate and synthesize these different approaches in a coherent way. This research applies logistic regression, network, and qualitative analyses to answer particular research questions, and incorporate those answers to capture a comprehensive picture of a relief logistics network. Integrating these different theoretical approaches through an abductive reasoning process, this research aims to create a new framework to explain evolutionary phenomena in a relief logistic network.

3.1 Research design: Abductive Research Framework

This research aims to propose a new framework of how each evolving mechanism at organizational, network, and system levels works independently and interdependently over-time coordination to improve the performance of a relief logistic network. To achieve this goal, I employ an abductive research process. The abductive approach introduced by Peirce is summarized as:

"Deduction proves that something must be; Induction shows that something 'actually' is operative; abduction merely suggests that something 'may be'" (Peirce, 1931, p.106, p.171).

The abductive reasoning seeks to understand the new phenomenon (Alvesson and Skoldberg, 1994, referred to Kovács & Spens, 2007) to suggest new theory (Kirkeby, 1990, referred to Kovács & Spens, 2007). An abductive reasoning, which has mixed attributes of

both deductive and inductive reasoning, is useful when a researcher finds a deviation in an empirical observation from existing theoretical framework. With this "puzzling point" (Alvesson & Sköldberg, 2017; Dubois & Gadde, 2002; Eco, 1983; Kovács & Spens, 2005), a researcher searches suitable theories to explain the puzzling point of the empirical observation, called 'theory matching' or 'systematic combining' (Dubois and Gadde, 2002). This search of theory matching starts in an attempt to find a new matching framework or to extend the theory used prior to this observation (Andreewsky & Bourcier, 2000). This study starts from puzzling points in the current cluster approach framework which neither explains of how such a clustering coordination approach can be achieved and whether this coordination format is effective to improve the entire system. Applying an abductive reasoning process, this study integrates and synthesizes different theories on the logic of a complex adaptive system framework.

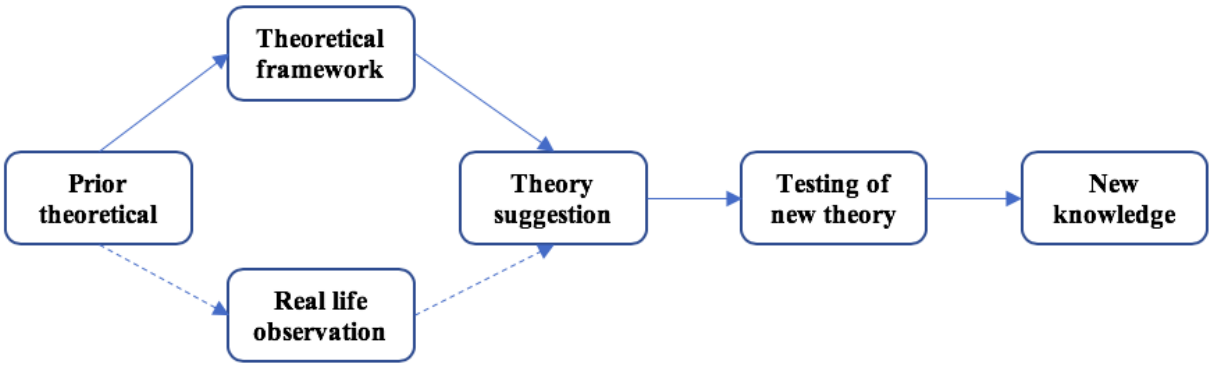


Figure 4 Abductive Reasoning Process

Figure 4 summarizes how to apply an abductive reasoning process in research (Kovács & Spens, 2005). This research begins with some prior theoretical knowledge from theories developed from diverse fields of study. For stage 1, this research introduces several relevant theories to help to understand strategic evolution processes which improve collective performance at organizational, network and system levels. The fundamental goal of a relief logistic network is to transmit allocated resources to the right place efficiently in response to a crisis. However, strategic plans to achieve that goal should be designed and developed based

on surrounding environmental factors which either undermine or enhance the performance of a relief logistic network. Thus, the relief logistic network should be understood within the surrounding environment. Using Institutional Analysis Development and Framework, I address the first research question in chapter 4.

To addresses research question #2 –what kinds of organizational similarities play a significant role in creating a strategic partnership to enhance individual organizational adaptations to a changing environment in a relief logistic network?—this research applies theories developed by sociology and cognitive studies to explain why individuals prefer people who share similar attributes, called 'homophily' propensity (McPherson, Smith-Lovin, & Cook, 2001). This approach has recently been applied to analyze the patterns of organizational collective behaviors to see how similar organizational attributes influence organizational choices to find their partners (Atouba & Shumate, 2015; Gerber et al., 2013; Heidarpour, Emami, & Shirazi, 2016; Song, Park, & Jung, 2018). To develop a new coordination framework in a relief logistic network, it is required to understand organizational behavioral perspectives of how individual participating organizations work together over time. To show the evolution of organizational behavioral propensities to create partnerships over time, this research analyzes continuous changes of organizational partnerships over time, not a single-time partnership. This analysis is presented in chapter 5.

As a result of continuous change in organizational partnerships, the features of a relief logistics network also keep changing. Network analysis is an appropriate approach to analyze a collective-level movement by interpreting the significance of certain features in the network structural evolution. This interpretation addresses research question 3— what are the major features of an evolving relief logistic network which focuses on shaping the efficient, resilient and coherent structure of the network? — by clarifying how those network evolution features

can contribute to achieving the collective goal in a relief logistic network. This analysis is presented in chapter 6.

The theory of fields provides the groundwork to integrate the organizational and network perspectives to derive system evolution and its performance. The theory of fields empathizes the changes in coordination strategies to improve the system performance in response to a changing environment (research question #4). As an iterative evolving system, I will explain how these coordination changes influence the evolving patterns in the organizational partnership process and network structural changes of a relief logistics network. By integrating these four theoretical approaches, I suggest a new coordination framework in a relief logistic network. This analysis is presented in chapter 7. To test its valueas a new framework as well as each theoretical approach, I use the 2014 Ebola crisis in Liberia as a case of a complex adaptive system.

3.2 Field Study Selection: The Ebola Crisis in Liberia 2014

For the selection of the cases, I first looked for an appropriate case to present dynamic changes in terms of environmental conditions, heterogeneity of individual organizations and their coordination process in a relief logistic network over time. The Ebola virus disease (EVD) outbreak devastated Guinea, Liberia, and Sierra Leone in 2014. The Ebola virus disease (EVD) outbreak devastated Guinea, Liberia, and Sierra Leone in 2014. Since then, EVD has affected more than 27,000 people, killing more than 11,000. Because the EVD outbreak was a catastrophic epidemic in the region of West Africa with vulnerable health infrastructure and management system, increasing aid was a major challenge (Dubois, Wake, Sturridge, & Bennett, 2015). In response to this chaotic situation, hundreds of organizations, including international organizations, national governments, NGOs and private companies, from all over

the world participated in responding to the Ebola outbreak through direct response activities in the field or donation of goods and money for meeting short- or long-term goals.

Interestingly, two major countries with the largest number of affected cases, Sierra Leone and Liberia, show distinctively different patterns of resource procurement pace and of the number of new Ebola cases under the same UN coordination system.

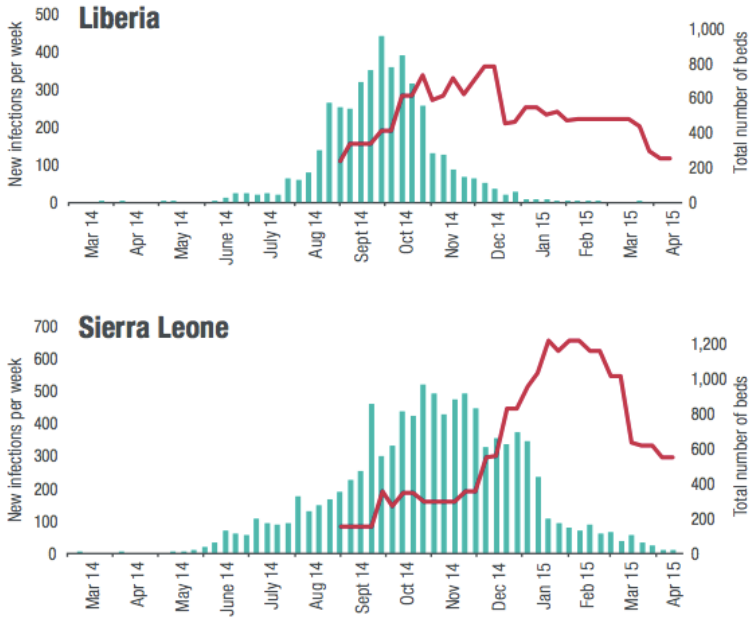


Figure 5 New EVD Cases and Hospital Beds in Liberia and Sierra Leone

Figure 5 shows that Sierra Leone showed a dramatic increase of the number of new affected cases per week with a slow increase of hospital beds until December 2014 (Global Ebola Responses, 2015). In contrast, Liberia had a rapid increase in the number of hospital beds until only the middle of October 2014 and kept the steady increase afterwards; the weekly number of new affected cases dramatically decreased after October 2014 (Dubois et al., 2015). This comparative picture captures the significant contributions of resource management to support the entire response activities, which ultimately decreased the number of affected cases. Particularly, Liberia, which was the worst affected country, became the first country to bring the disease under control among the affected countries. In this reason, Liberia serves as a good

example to show how a coordination system in a relief logistics successfully succeeded within the short-term.

Figure 5 reflects that the dramatic increase of medical aids in Liberia started in late August, 2014 when the UN system officially declared the international emergency calls to drive an international collective effort in response to the Ebola crisis. Under the current international response system, an international relief logistics network is set up after an international emergency call. This research focuses on the period from the set-up of the relief logistic network in September to the settled-down state of the relief logistic network with diminishing number of weekly new affected cases in December, 2014. Aiming to capture the evolving trends of the relief logistic network, this research divides the response period into four phases according to dynamic situational changes in Liberia.

3.3 Unit of Analysis

The observation was made at the level of participating organizations in a relief logistic network in Liberia, because a relief logistics network is composed with organizations which have particular resources, expertise, and techniques to serve a certain type of logistic activities. These participating organizations varied in locations, expertise, and institutional characteristics such as funding sources. Through observing organizational data, this research analyzes the evolving patterns of these diverse participating organizations to create collective action in the relief logistic network in response to the 2014 Ebola crisis in Liberia.

3.4 Methods: Mixed-Method Approach

Using an abductive reasoning process to integrate different theoretical approaches, this research applies different types of methodologies to appropriately analyze phenomena derived by different theoretical approaches.

3.4.1 Logistic regression: Organizational partnership pattern

The first step is to analyze individual organizational behavioral patterns in creating partnerships by applying logistic regression. Unlike standard linear regression analysis based on ordinary least squares (OLS) estimates, it relies on maximum likelihood estimates. The most distinguishing characteristics of logistic regression is that it can be used to analyze dichotomous dependent variables coded as Yes (1) or no (0). Binary logistic regression offers probabilities of success or failure, which are predicted by independent variables: the log odds of an event. The general form of the log-odds (here denoted by ℓ) is:

$$\ell = \log \frac{p}{1-p} = \beta 0 + \beta 1 x 1 + \beta 2 x 2$$

As the partnership status between two organizations was coded as yes (1) or no (0), this research utilizes logistic regression analysis to figure out to what extent each organizational attributes can predict organizational homophily partnerships over time.

3.4.2 Social network analysis: Network structure

To identify the interaction patterns of the network, this research applies a social network analysis (SNA). SNA is defined as an array of social relations (tie) among social actors (nodes). The social actors in this research are participating organizations in a relief logistic network in

response to the 2014 Ebola crisis in Liberia. The social relation (tie) in this research is symbolized as an information or resource flow between two organizations. SNA focuses on analyzing structural characteristics of networks formed by a number of connected actors across multiple levels, rather than characteristics of each nodes. The multi-level approach of conceptualization enables researchers to not only see the relative contribution of each network level partaking of phenomena but also to study how these levels interact with each other to drive such phenomena (Prell, 2012, p.3). Taking a multi-level approach highlights the interdependency among multiple operational levels to improve the system performance in a relief logistics network. SNA has a big advantage to analyze interaction data without the limitation of the number of interactions. Unlike other statistics methods, the size of data could be very small or unlimitedly large depending on a researcher's research boundary. Meanwhile, SNA does not provide interpretation of the SNA result. To be specific, even though SNA measures how a network is structured efficiently as a whole, the structure itself does not explain internal mechanism to drive a certain format of network structure: why and how. To understand the results of SNA, it is recommended for a researcher to apply other analysis methods, such as a qualitative method, which can provide in-depth information to explain and interpret the network structure and its changes reflecting a certain context of the research (Bilecen, 2013).

3.4.3 Qualitative analysis: System performance

This research applies qualitative analysis to extend the understanding of mechanisms embedded in logistic regression analysis and SNA by analyzing interview data and various types of documents. In order to collect in-depth information about procedural dynamics and evolving process of collective action systems, I conducted semi-structured interviews. A semi-structured interview is an in-depth conversation between a researcher and subjects for a certain purpose. In the semi-structured interview, the researcher has a specific topic to learn about,

prepares a limited number of questions in advance, and plans to ask follow-up questions. Through interviewing the subject, the researcher explores in detail the experiences, motives, and opinions of interviewees and learns to see the world from the subject's perspective rather than their own. By listening and watching the subject during the interview, the researcher can capture hidden or deeper meanings of what the subject reports. Also, the researcher can capture the on-going process of the situation, which helps to improve one's understanding of mechanisms (Rubin & Rubin, 2011). Interviews with participating staff as representative managers or practitioners from participating organizations provide explanatory information of evolving mechanisms at an individual organizational level, a network structural level, and a system level through coordination processes of a relief logistics network during a crisis.

Content analysis of various kinds of documents contributes to enlarging a researcher's understanding of differences between theory and reality. Content analysis follows the logic of process tracing which includes deductive and inductive aspects (Andrew, 2008). While process tracing shows how well theoretical principles are realized in the field, it also helps researchers inductively complement the principles by reflecting a unique context. Content analysis provides rich information of internal and external environments which play critical roles in influencing the performance of the system. This rich information expands a researcher's background knowledge to interpret data analysis results from statistic and interview analyses. Furthermore, the content analysis plays an important role in validating interview data by reflecting what really happened in the field. Interviewing is a retrospective process that relies on interviewees' memories. Because their memories might not be precise in terms of the timeline of certain activities and the performance of those activities, a researcher needs to make cross-checks between interview data and content analysis data from documents to improve the validity of the analysis.

By integrating and synthesizing the analysis results from the organizational partnership patterns from logistic regression, network structures from SNA, and evolving mechanisms of individual organizations and networks, this research focuses on the system performance measured with the number of affected cases. The integration of separate results derived by different analyses will provide a comprehensive framework that matches the dynamic patterns of organizational behavioral patterns, the relief network structure, and the system's performance.

3.5 Data Collection Procedure

3.5.1 Data collection 1: Documentation review

First, extensive documents were reviewed to collect data about contextual environment, procedural complexity and dynamics, and outcomes of collective action systems in a relief logistic network in Liberia. The contextual environment is measured in terms of Liberian geographic, historical, political, governance, social, economic and infrastructure features. These environmental features shaped the field characteristics to either undermine or enhance the performance of the relief logistic network. To collect general information of the country, I used open source like national profiles from encyclopedia websites and national government websites. In addition, I analyzed various types of documents, which focused on the 2014 Ebola response in Liberia, archived at ReliefWeb. ReliefWeb is a specialized digital service of the United Nations Office for the Coordination of Humanitarian Affairs (OCHA). Participating organizations in humanitarian crises, including international organizations, national governments, NGOs, companies, and news agencies, upload diverse kinds of documents ranging from working reports, news and press releases, research papers to working maps. Since

the documents ReliefWeb archives covers public, non-private, and private sectors, the process tracing by using these documents presents a comprehensive picture concerning what kinds of policies were implemented and how local people reacted to the policies throughout the time within a particular context. The content analysis for this study focuses on the time period from the establishment of unified Ebola coordination system in September to the stabilized coordination system in December 2014. I exclusively collected and analyzed documents written in English related to the 2014 Ebola crisis in Liberia archived from the ReliefWeb: 379 articles in late August to September, 394 in October, 304 in November, and 303 in December. The document review was conducted from December 2015 to August 2016.

3.5.2 Data collection 2: Network coding

From these reviewed documents, I identified participating organizations (nodes) and their interactions (ties) in the relief logistic network. Those connections are completed when a partner organization accepts any type of resources or information from an initiating organization. As a directed network, I identified the initiating organization (initiators) and the recipient organizations (respondents). The tie was counted as a part of relief logistics activities— preparedness, planning (assessment), procurement, transport, warehousing, tracking and tracing, and customs clearance (Thomas & Kopczak, 2005). To identify those organizations, I categorized the entire set of participating organizations according to funding sources (Modified from Comfort, 2007; Comfort et al., 2009) — international-public, regional-public, national-public, private, nonpublic—and organizational headquarter locations (Comfort, 2007; Comfort et al., 2009; Kapucu, 2005)—International, North America, Europe, Africa, Others. Organizational operational levels in a relief logistic network is categorized as international, national, regional, and local based on Liberian jurisdictional levels. Organizational functions in the relief operations are categorized as relief operation coordinator,

logistics services, donors, military, telecommunication, field operators and health facility operators (Modified from Cozzolino, 2012). This coding process included five revising processes from December 2015 to March 2018 to get the final version.

Table 1 Coding Scheme

Concepts	Category	Definition
Organizational tier	International organization	An organization supported by international public funds (through international member states)
	Regional organization	An organization supported by regional public funds (through regional member states)
	National organization	An organization supported by domestic public funds (through citizens)
	Private organization	An organization supported by private funds or investments
	Non-profit organization	An organization supported by voluntary donations
Original location	International	Headquarter office(s) are located in several places in the globe.
	North America	Headquarter office(s) are located in U.S. or Canada
	Europe	Headquarter office(s) are located in European countries
	Africa	Headquarter office(s) are located in African countries
	Others	Headquarter office(s) are located in other places which are not fall under aforementioned locations
Operational level	International level	Outside of an affected country
	National level	Central government division of Liberia
	County level	Local administrative division
	Community level	Smaller social boundary governed by a certain county
Organizational role	Coordinator, logistics services, donors, military, telecommunication, field operators, and Ebola treatment units (ETUs) (See details in Chapter 6)	

3.5.3 Data collection 3: Logistic regression coding

Data for logistic regression was prepared by transforming the directed network interaction data into the logistic regression format. The network data set only captures valid interactions between organizations. In contrast, the logistic regression needs information for both valid interactions and no interactions among all participating organizations out of all possible connections in a relief logistic network. First, I created all possible interactions among participating organizations from the network coding dataset. And then, I coded their valid/absent interactions. For example, there are connections between A and C, B and A, and B and C in a relief logistic network. If there is a connection between two organization, the dependent variable is coded as 1: otherwise, 0. (see details in Table 2)

Table 2 Data Coding Process 1: Creating All Possible Connections

Initiating Org	Recipient Org	Connection (Dep)
A	B	0
A	C	1
B	A	1
B	C	1

This data format does not include organization C as an initiating organization, because organization C has never initiated any connections with other organizations in this directed network. Some organizations only play a role as recipients during a response period particularly if they are pre-assigned by donor organizations to serve a certain task with a one-time resource allocation.

After creating the dependent variable, independent variable columns were created to indicate the matching status of organizational attributes between two organizations. Independent variables are coded as 1 if organizational attributes are the same between two organizations: otherwise, 0. For example, A organization is a national government from Africa region and B organization is a non-profit organization from Africa region, and C organization

is a national government from Europe region. The independent variable column as a result of matching process based on the organizational attributes is shown in Table 3.

Table 3 Data Coding Process 2: Matching Organizational Attributes

Initiating Org	Recipient Org	Connection	Funding Source	Location
A	B	0	0	1
A	C	1	1	0
B	A	1	0	1
B	C	1	0	0

This whole process was applied to every organizational attribute: organizational tier, original location, operational level in a relief logistic network, and organizational role served in a relief logistic network. This coding process was conducted from July 2018 to November 2018.

3.5.4 Data collection 4: Semi-structured interview coding

3.5.4.1 Selection process of interview subject

This preparation helped both a researcher and interviewees to focus more narrowly on the research question in detail (Rubin and Rubin, 2012). Information about the changes of coordination process over time and the changes of organizational perceptions towards other participating organizations is rarely published in existing documents. Thus, direct communications with staff who worked as an organization's representative or practitioners in a relief logistic network were the best way to obtain appropriate information about how they coordinated to overcome internal and external challenges and changed their actions in a particular way accordingly.

To select major supporting organizations in the relief logistic network in Liberia, first, I used the stratified sampling strategy by referring to the network database and documentation

reviews. From the descriptive analysis of the network data for each month through September to December, I screened organizations that consistently participated in the network at a central position; their central location in the network implies their significant influence over other organizations in collective decision-making process in the network. Meanwhile, documentation reviews allowed me to have in-depth understanding of those organizational roles and their contributions to the network. The documentation reviews also provided significant information about some organizations that were not frequently captured in the network data but made significant contributions in improving the entire performance of the network.

To validate my first selection of potential interview subjects, I had pre-interviews with two managers from the U.S. Center for Disease Control and Prevention who participated in supporting a coordination process between U.S and the unified EOC in Liberia during the Ebola outbreak: One in-person interview in Atlanta on March 27th 2017 and one phone interview on April 7th 2017. These interviews helped me to have background knowledge of the field operations and to figure out which organizations I would need to contact in Liberia. Based on this screening process, I selected 20 international and national organizations that played a significant role of coordination, logistics service provision, military, and donation to support the Ebola operations in the network.

After pre-interviews, I conducted face-to-face interview in Liberia from April 16th to April 26th 2017 in Liberia. The interviews were confidentially conducted face-to-face at interviewee's offices or their designated sites. I started face-to-face interview with staff members from major participating organizations recognized during my pre-interviews in U.S. During this interview process, I realized that many local organizations which were never documented in official reports from the ReliefWeb significantly contributed to the network as last-mile logistics services, field operations, and Ebola treatment units at the county and

community levels. I contacted those organizations recommended by my interviewees in Liberia. I met seven staff affiliated to Liberian organizations that supported field operations and Ebola treatment centers in the affected and counties and communities. Since those staff worked as not only organizational representatives but also community members in the affected counties and communities, their experiences and perspectives were different from the foreign organizations that mostly worked at the national level. The two additional interviews after the field interviews were conducted as an in-person interview in Pittsburgh on May 8th 2017 and a group interview on the phone on April 11 2018. The average time taken for interviews was around 45 minutes. The interviews were audiotaped and noted with the consent of the interviewees.

As a result, this research conducted interviews with personnel from 24 organizations. Specific informant interviewee(s) were selected and introduced by each participating organization. Since several organizations served multiple roles in the relief logistic network, each organization provided one to three interviewees who served different roles. In total, 34 organizational representatives or practitioners including international organizations' and Liberian government officials, chief and field managers in international and local NGOs, and volunteer staff. Table 4 provides summarized information about the interviewees.

Table 4 Information of Interviewees

Organizational Role		Organization's Operational level	
Coordinator	12	International	4
Logistic service provider	9	National	14
Military	2	County	10
Donor	1		
Field operator	9	Community	6
Ebola Treatment Unit	1		
Total	34	Total	34

3.5.4.2 Interview process

All interviews were conducted by a semi-structured format protocol that incorporated a common set of open-ended questions. The interview aimed to elicit detailed information about the coordination detailed process and its performance. First, the interviewees were asked to describe major roles or functions of their organizations within the relief logistic network, and to describe contextual challenges in a coordination process. Second, the interviewees were asked to share what efforts (strategies) those participating organizations made to overcome such challenges in the coordination and how those efforts worked either to improve or undermine their collective performance with specific examples. The third set of questions focused on organizational perception toward other participating organizations in the relief logistic network. In a collective action system, organizational perception plays a critical role in creating partnerships with certain types of organizations. Thus, this set of questions aimed to draw information regarding 1) what strategies those organizations collectively exercised to improve the coordination and collaboration performances, 2) how those strategies worked to overcome challenges, and 3) how organizations changed their behaviors in coordination individually and collectively.

The interviewees were asked to illustrate particular situations in their answers. Because those situational illustration included specific conditions and context of their coordination environments, I could check those detail information corresponding with the general information captured in documentation reviews. By adding the respondents' experience, thoughts, and interpretations of reality to represent their affiliating organizations, the semi-structured interview processes enriched my understanding and interpretation of how the entire system evolves; how a coordination mechanism changes evolving processes at individual organizational, network structural, and system levels, ultimately results in changes of system performance.

3.5.4.3 Additional data

In addition to the interview data, I also analyzed the transcription of an international meeting held in Geneva on May 13, 2017, which purposed to review the international coordination and collaboration system in response to the Ebola crisis. Hosted by Humanitarian Policy Group (ODI), five major organizations— World Health Organization, Liberian government, USAID representing U.S government, MSF Switzerland, International Committee of the Red Cross (ICRC)— as international representative coordinators during the Ebola crisis participated in this meeting. Following the pre-set questions provided by a meeting moderator, the representatives from these participating organizations focused on specifically answering their perspectives toward the international collaboration performance revealed in the Ebola response. After each organization's remarks, those participating organizations had open discussion time by refuting others' answers and asking follow-up questions of one another. The panel discussions provided critical insights into the Ebola crisis response process embedded in a structural problem of the current international collaborative system. Thus, I included this meeting transcription as a part of semi-structured group interview.

3.6 Validity and Reliability

The value of empirical research is determined by how to resolve potential threats of validity and reliability. A mixed-methods research design can provide different perspectives of information on a research phenomenon by using diverse methodologies. A mixed-method design is prone to threats to validity and reliability at various levels. Thus, this section summarizes particular threats to validity and reliability existing in this research with steps taken to control and resolve those issues in research procedures.

3.6.1 Validity

The validity issue comes from whether the research measures the intended concepts. The major concept of this research is the complexity and dynamics of collective action evolving process in a relief logistic network. Based on the theoretical framework, the concept was divided and measured into three levels: organizational, collective, and system levels. Second, to avoid single source or methods bias in measuring concepts, multiple sources and instruments are applied to observe and examine these complexity and dynamics. I incorporated data from multiple media releases, operational reports provided by diverse participating organizations, coordination meeting records, and journal articles which assessed the Ebola response operations. These data were published by a number of diverse organizations that reflected different orientations, perspectives, or emphases even for the same situation. In addition, the semi-structured interviews were compared with those content analyses, the network coding, and the WHO's statistical data of the number affected cases during the operational period. The comparison among three different data sets captured the interdependency of organizational perceptions with the system performance in the real world. To strengthen the inference validity of the logistic regression analysis result, I carefully developed measurements based on existing theories, and those measurements were coded based on the facts reported in the reviewed documents and organizational websites. Lastly, I employed interview protocol from reliable sources that had already tested the connection between concepts and the measurements. The number and types of interviewees from participating organizations also well represented approximate population of the Ebola relief logistics network. Since this research aimed to suggest a new framework of coordination in a relief logistic network, the generalizability of the study results would require continuing research for different contexts, including other types of disasters and different internal and external contexts. This study was carefully developed on

theoretical backgrounds and methodological refinements to minimize the threats to the external validity. This study offers a critical baseline assessment whose design is replicable for the future research and further explorations.

3.6.2 Reliability

Reliability addresses whether measurements for concepts are consistent and stable to ensure the dependability of the results of the study. First, all the data collection, coding, and cleaning procedures were conducted and managed by the author only: no risk for inter-coder reliability issues exist in the resulting data set. In addition, the set of databases was checked multiple times to minimize perceptual errors and enhance the consistency of the data. With respect to the reliability of network data, I used newspaper articles and official operation reports provided by diverse sources. Because these documentary data sources were recorded in real time, I could prevent errors caused by any personal cognitive bias which is usually found in recollection of past interactions. In addition, I designed and followed the network-coding manual prior to actual coding so that I could keep consistency to collect the network data throughout the entire coding procedures.

In order to obtain the reliability of the data from the interviews, I employed a stratified sampling method that maximizes the variance of experiences and opinions reflected in different perspectives of participating organizations. I used face-to-face methods to conduct interviews so that I can obtain higher understanding of the contexts through respondents' subtle expressions in their gesture, mood, and tone as well as higher rates of return. In addition, I closely followed standard procedures and protocol for the interviews in order to minimize errors from interviewers' biased questions or attitudes (Kerlinger and Lee, 2000).

3.7 Summary

Table 5 Summary of Methods and Data

Research Question	What are major coordination features and strategies of humanitarian relief logistics system to improve the entire response operations where a great number of diverse types of participating organizations need to drive a collective action under uncertain complex situation?	
Research case	The 2014 Ebola outbreak in Liberia	
Unit of Analysis	Participating organizations in a relief logistic network	
Question 1	Analysis method	Document review
	Data	1,380 documents archived from the ReliefWeb
Question 2	Analysis method	Logistic regression analysis
	Data	1,380 documents archived from the ReliefWeb
		(Supplement) 34 interviewees from 24 participating organizations
Question 3	Analysis method	Social network analysis
	Data	1,380 documents archived from the ReliefWeb
		(Supplement) 34 interviewees from 24 participating organizations
Question 4	Analysis method	Qualitative analysis
	Data	34 interviewees from 24 participating organizations
		1,380 documents archived from the ReliefWeb

4.0 Research Case: The 2014 Ebola crisis in Liberia

The first emergence of the Ebola virus disease (EVD) was identified in 1976 in South Sudan and Democratic Republic of the Congo. Since that point, the Ebola virus has recurred intermittently in tropical regions of sub-Saharan Africa. Between 1976 and 2013, the World Health Organization reports a total of 24 outbreaks involving 2,387 cases with 1,590 deaths (WHO, 2018). When developing strategies to mitigate an Ebola virus outbreak, policymakers should consider critical contextual factors, including formal and informal institutions as well as physical environmental factors, because interactions among those formal and informal institutions and characteristics of the Ebola virus create an uncertain physical environment. This unique environment requires a certain type of relief logistics network which can address certain needs in response operations. If the relief logistics network quickly resolves the situational needs, the damage from the virus is minimized. In this context, coordination in a relief logistics network plays a critical role in collecting this critical contextual information, predicting uncertain situations possibly created by such contextual factors, developing policies to mitigate expected uncertain situations and supporting policy implementations (Charles et al., 2010; Oloruntoba & Richard Gray, 2006; Scholten et al., 2010; Van Wassenhove, 2006). Contextual information is essential for the readers to understand what kinds of relief logistics network was required and why some coordination strategies did or did not work successfully in response to the 2014 Ebola crisis in Liberia.

This chapter investigates both the international and domestic contexts which provide the information of an external environment surrounding the international collaboration system in response to the Ebola crisis in Liberia. An international context is the realm where an international collective action in response to the Ebola crisis was established by an international agreement—currently, international cluster approach— which serves as a ‘rule of game’.

However, if the international environment does not have enough capacities to implement in the real field, or if the current international approach does not well fit to the real field, the participating organizations in the collective action needs to modify the existing rules or improvise new rules to fill the gap of international and field capacities. The immediate establishment of international collective action system in the field serves as an essential role in developing an adjusted collective system. Domestic context provides the fundamental ground to support international collective action including the set-up, management, and implementation of a relief logistics network. If the domestic institutional environment cannot provide the conditions that support the successful implementation of the international collective action system, the participating organizations need to figure out how to modify the existing system to fit the particular domestic context in the field. The critical investigation of both international and domestic contexts serves as a guideline for coordination to enable the system to respond successfully to the Ebola outbreak.

This chapter introduces how contextual factors interacting with characteristics of the Ebola virus created unique environments where uncertain challenges undermined the effectiveness and efficiency of a relief logistics network. This research introduces five institutional factors in Liberia—1) the environmental situation, 2) the governmental situation, 3) the public health situation, 4) the infrastructure situation, and 5) social cultures and norms—embedded in international and domestic contexts in response to the Ebola crisis in a chronological manner. Thorough investigation of these contextual factors helps to identify core strategies required in the Ebola relief logistics network in Liberia.

4.1 Before the Ebola outbreak: Existing International and Liberian Domestic Contexts

4.1.1 Environmental Context

Situated on the Atlantic coast in the southern part of West Africa, Liberia shares borders with three countries: Guinea to the north, Cote d'Ivoire to the east, and Sierra Leone to the northwest. Liberia has a total area of roughly 111,000 km, which is a similar size with Tennessee State in the U.S. Of the 96,000 km of land in Liberia, few areas are used for agriculture. While 3.43% (about 3,300 km) is arable, only 1.98% (about 1,900 km) is used for permanent crops out of the entire land (96,000 km); inland of the country is covered by a grassy plateau. The country's southwest coast area is composed of rivers and lakes including mangrove swamps, lagoons, and sandbars. The northeast portion of the country where rolling hills and some low mountains are concentrated is covered by rainforests (Liberia Media Center, 2008). The climate is characterized as tropical, hot and humid all year round, with a heavy rainy season from May to October due to the African monsoon, and pretty frequent rains in the other months, except in the short dry season that runs from December to February (Petterson, Jones, & Holsoe, 2018). Liberia is made up of fifteen counties. Montserrado, one of smallest counties at roughly 1,900 square kilometers, is the most populated with nearly 1.2 million people, owing to the country's capital city within its borders (Petterson et al., 2018).

Figure 6 Map of Liberia (Referred from Vidiani.Com, 2011)

4.1.2 Governmental Situation: Historical, Political and Economic Conditions

4.1.2.1 International context

There are two parallel situations between public health and other humanitarian crises at the international governance level (See details in Chapter 1). The World Health Organization's leadership in response to an international public health crisis has shrunk. Under the terms of the 2005 International Health Regulations, member states were responsible for developing national disease surveillance and response capacities to prevent the international spread of disease, while the WHO's role is limited to provide technical support to those countries whose capacities were insufficient to meet those surveillance requirements. The WHO's role and autonomy regarding to issuing travel advisories, which might cause economic damage was limited by member states after the 2009 SARS outbreak when member states claimed that the WHO over reacted to the outbreak (Kamradt-Scott, 2016). The member states as the principals

have strongly restricted the WHO's authority through direct and indirect means. One example of the member states' opposition is that WHO's organizational capacity has decreased in terms of budget and human resources. The number of staff members decreased from 90 to 36 people in response to a 51% spending cut by member states in 2013 to the WHO's 'outbreak and crisis response' budget for 2014–15 (Butler, 2013). However, according to the WHO's director-general, the 2014 EVD outbreak created demands on the organization 'more than 10 times greater than ever experienced in the almost 70-year history'(Kamradt-Scott, 2016). Also, the management structure within the WHO was disjointed. The WHO was divided into seven separate organizations (6 regional and one central office). This regional management structure has long been identified as an impediment to effective collaboration in the event of an international emergency as the regional offices are largely separate and autonomous from the central headquarters in Geneva. Multiple reviews of the WHO's operations revealed a raft of inefficiencies, duplication of services, poor health outcomes and unhelpful infighting, but the member states have resisted calls to significantly redesign the WHO's organizational structure (Wenham, 2016).

4.1.2.2 Liberian domestic context

The government serves as a country's fundamental authority to deal with emergency situations. Without a stable political situation and economic and social capacities to deal with a crisis, the national authority cannot enact and support policies with the necessary resources. Africa's first republic country, Liberia was founded in 1822 when the American Colonization Society made efforts to resettle freed American slaves in West Africa. Over the course of forty years, about 12,000 slaves were voluntarily relocated. The colony became the Free and Independent Republic of Liberia in 1847. The Liberian government followed the U.S model to set up a government system with a presidential election. Traditionally, agriculture substantially

contributed to Liberia's GDP. Before the outbreak of the civil war in 1989, the country had an evolving rubber industry, which accounted for almost US$100 million in exports annually. In addition, the discovery of iron ore in the late 1950s gave another driving force to the country's economic growth. In the 1960s and 1970s, Liberia was one of the major exporters of iron ore (Economy Watch, 2010).

Since 1980, Liberia has gone through continuous political instabilities: a military coup in 1980 and political rebellion in 1989 which caused a long-term civil war until 1997 when Charles Taylor took power through the Liberian general election. This eight-year civil war took a major toll on the infrastructure, virtually destroying the health care system and eliminating the electrical system and access to water in most of the country. The civil war also led to tremendous economic deterioration (Encyclopedia, 2019). The rubber and iron industries were the most exploited since they were used to generate foreign currency (Economy Watch, 2010). After the restoration of a democratic government in 1997, the unstable political situation continued with rebellious movements toward President Charles Taylor's corrupt administration and eventually led to the second civil war during 1999-2003. By the time the corrupt administration was exiled, the Liberian government was almost bankrupt and had siphoned off $100 million leaving Liberia the world's poorest nation (Infoplease, 2017). The industrial sectors contributed 5.4% to the country's GDP and approximately 8% of the employment rate (Economy Watch, 2010). During the military regime and the civil war period, the Liberian economy was heavily exploited. The national human development organization has stated that 75% of Liberia's people live of less than a dollar a day.

4.1.3 Public health conditions

The key indicators of public health in Liberia include: basic nutrition, sanitation, and healthcare services. Without proper nutrition, people are not only more susceptible to diseases

but also have more difficulty to recover from illnesses, even if there is proper medical treatments. Basic sanitation is important to prevent dehydration, waterborne epidemic diseases, and other viruses which spread through bodily fluids. The national healthcare services provide the fundamental foundation of citizens' immediate access to medical services. If the affected country does not have adequate healthcare facilities, supplies and staff, the medical relief operations need to substantially depend on foreign aid support from the beginning to the end: building appropriate health facilities, providing essential medical supplies and staff, and caring for patients until fully recovered. This heavy reliance on international aid requires lots of coordination and logistic support, which delays the entire relief operation.

4.1.3.1 Basic nutrition and sanitation status

Decade-long civil wars substantially degraded the living conditions to the extent that the majority of the population live in slums. Around 60% of the population—approximately, 2.5 million people— live below the poverty line. This nation-wide poverty broke down two fundamental public health conditions: nutrition and sanitation. Malnutrition is widespread; 40% of Liberian children have unnatural stunted growth and 7% of Liberia's population have highly acute malnutrition. This high level of starvation and malnutrition is linked to a severe lack of food and the lack of pre-and post-natal care and educational resources for young mothers (UNICEF, 2016). This vicious cycle of chronic malnutrition has led to a very high level of pre-mature births and high mortality rates among children under 5 years of age. Malnutrition also increases the chances that a child will contract febrile, malaria, diarrheal diseases, or lower respiratory infections.

Also, poverty has limited people's access to clean water and sanitation. In some instances, up to 10 people share the same toilet without disinfectant and potable water. For every four people living in Liberia, there is one living in unsanitary conditions without access to any clean

drinking water; one in five deaths are due to consuming contaminated drinking water. According to the 2008 National Census, access to piped water fell to less than 3 percent. WHO reports that due to unsanitary conditions and the widespread practice of public defecation, 58% of Liberia's water was contaminated with E coli which causes diarrhea and vomiting, both of which further exacerbate the problems associated with dehydration and malnutrition (Wikipedia, 2017) . The water crisis in Liberia has reached catastrophic levels.

4.1.3.2 Health care services

Of Liberia's 550 pre-war health facilities, only 354 facilities (12 public hospitals, 32 public health centers, 189 public clinics, 10 private health centers, and 111 private clinics) were functioning by the end of 2003. The rest were destroyed in the conflict. Also, during the civil wars, many health workers escaped abroad, which, in turn, led to a great lack of national health workers. For instance, over half of the doctors born in Liberia work in Organization for Economic Co-operation and Development (OECD) countries (Sharples, 2015). WHO recommends a minimum of one health care worker for every 439 individuals. However, Liberia had 3,472 people for one health worker (Save the children, 2015). Therefore, Liberia relies heavily on international partners (NGOs and faith-based organizations) to fortify the workforce, supplying personnel at the managerial level as well as providing training and paying for frontline health workers. Of the 354 remaining facilities, 80% were managed by non-governmental organizations (NGOs) and faith-based organizations (FBOs), thus highlighting the huge tasks that the government faced to ensure its population received a modicum of basic health care (Patrick, 2017).

Providing health supplies in a timely manner is another challenge. The health facilities do not have sufficient medical supplies such as basic medicines, specialized equipment, and sanitation items. The Liberian governmental health spending of $16 per person is far below the

WHO recommended minimum of $86 per person to support minimum package of essential health services (WHO, 2015). Since the health system is funded by the government, health workers have suffered from frequent non-payment of salaries. This dire situation has contributed to poor morale of the national health providers. Public trust in the national government and health care system has been further eroded by schemes to sell fraudulent vaccines to citizens while officials pocketed the money. Prior to the Ebola crisis, 40% of patients reported paying bribes to obtain health services (Transparency International, 2015). Particularly, rural areas have a substantial gap of health delivery which led to more than two-thirds of Liberian households being unable to access proper health services (Patrick, 2017).

Furthermore, the poor condition of the health system increased the costs to patients for visits to public health facilities. Those health facilities were concentrated in urban areas and due to a lack of vehicles, most people spent several hours walking over poor roads to get to the hospital. Because most areas don't have public medical facilities nearby, it is very costly for them to visit the facilities when taking account of the cost of transportation, time and expensive medical fees. This is especially for the more than 60% of the population in rural areas that are living with less than 2.5 dollars for a daily income (World Bank, 2015). To rural residents, their travel time is an opportunity cost of their daily income, sacrificing to feed their family members (Dubois et al., 2015).

Due to the mistrust toward the formal healthcare system and difficulty in accessing medical care, many Liberians rely on informal medica providers such as spiritual healers and drug peddlers who charge less money and are more accessible within rural communities. Despite scientifically unproven practices that in many cases may be dangerous, traditional healers are often the only option for residents in rural communities. Traditional healers have a strong reputation in traditional communities and are trusted by the residents. The number of visits to traditional healers outnumbers visits to formal medical facilities by a ratio of 3 to 1 (Kruk,

Rockers, Tornorlah Varpilah, & Macauley, 2011).

4.1.4 Technical infrastructure conditions

The technical perspectives illustrate the condition of the public infrastructure including the logistics, information and communication infrastructures. The logistics infrastructure including road conditions, ports, and airports plays a critical role in expanding access to physical and human resources especially for nation-wide operations including isolated rural areas. Without a strong logistics infrastructure operational plans cannot be activated. The information and communication infrastructure play a critical role in supporting nation-wide coordination. In time-sensitive situations with fast-changing environments, like the Ebola crisis, national response operational plans need continuous modifications by reflecting the current situation in real time. Therefore, having diverse communication means across different coordination levels from international to national, county, and community levels provides successful conditions of multi-level coordination. In terms of the communication with the public, certain communication channels are publicly accepted as trustworthy and reliable sources, which are important to consider in community mobilization activities (ACAPS, 2015).

4.1.4.1 Logistics infrastructure: Roads, ports and airports

The long-term civil wars also caused heavy destruction to the transportation infrastructure facilities including roads, bridges, and ports. Roads play a critical role of nation-wide inland network to support human and resource mobilities because of the marginal level of rail networks; there are no passenger rail services, and the iron ore rail transport links require serious repair as large sections of the rail network were destroyed during the civil wars (Foster & Pushak, 2011). However, less than 40 % of the country's primary road network is paved (Infoplease, 2017). Most of road networks connecting to rural areas are dirt roads which

become muddy and marshy during the heavy rainy season. Frequent rain on unpaved roads creates many challenges to maintain passable conditions. Even though rehabilitation and maintenance of road networks are required to increase human and physical resource flows, the Liberian government spent less than 40 % of the planned capital spending for inland network rehabilitation and maintenance (Foster & Pushak, 2011).

The country's 5 ports, located in Monrovia, Buchanan, Greenville, Harper, and Roberts, handle 200,000 tons per year in general cargo and 400,000 tons a year of petroleum products. Ports in the south-east of the country handle timber exports. Liberia has taken swift and comprehensive action to improve the situation at the Freeport of Monrovia. This new approach includes major reconstruction, ranging from physical construction to expand the port's accessibility to organizational governance reform by involving private participation, which ultimately aims to improve efficiency. In 2010, the National Port Authority has substantially been downsized to 750 personnel through considerable layoffs from front line cargo handling operations. Due to the downsizing of the front-line cargo handlers, the port has not been able to keep pace with anticipated traffic growth (Foster & Pushak, 2011).

Roberts airport, the only international airport located 35 miles from Monrovia, was destroyed during the civil wars in 1990. Before the Ebola crisis occurred, the international airport carried some regional commercial flights but needed major repairs to carry international flights. Liberia's air transport market is the smallest in the West African region. Liberia's air transport declined substantially between 2001 and 2004, which reflects the decline in the number of important regional airlines providing immediate access to other countries in West Africa. While the overall number of seats has increased significantly, the number of city pairs served—nine in total—is no larger than it was in 2001 with fewer intercontinental flights and more intra-African flights. Liberia's main air connections are with Ghana, to which flights were available almost daily in 2007, and (to a lesser extent) Cote d'Ivoire. Accra is effectively acting

as a local hub for Liberia. While midsized aircraft grew, large and smaller planes did not come into Liberia. Because of limited space and a lack of human resources and unloading equipment, only two flights are allowed to land per day (Encyclopedia, 2019; Foster & Pushak, 2011).

4.1.4.2 Information and communication infrastructure

During the civil wars, the country's power generation network was completely destroyed. The limited access to electricity –only 16% of households in urban areas and 1% in rural areas— has restricted access to many communication channels. Written forms of communication such as newspapers and magazines are not popular as information sources particularly in rural areas where people usually have much lower levels of education and higher illiteracy rates (LISGIS, 2014). A pocket radio or a radio application installed in a mobile phone, which is not affected by low rates of adult literacy, high poverty rates, and limited power supplies, has played a major source of getting news and currently important information. Listening to a radio source and sharing the information together serves as not only an important socializing activity in the community but also a critical channel to inform people especially in a rural area. Therefore, traditional channels such as word of mouth or community leaders were considered as a trustworthy information sources (ACAPS, 2015).

Since 2003, a modern wireless telecommunication has rapidly grown as a major telecommunication industry. Liberia's mobile wireless coverage rate –the percentage of the population living within range of a mobile signal and hence able to subscribe to service— grew substantially between 2003 and 2009, from 18 percent to 32 percent (Foster & Pushak, 2011). Liberia's 2013 Demographic and Health Survey shows that the mobile phone ownership has rapidly increased from 20% in 2007 to 65% in 2013 (National Demographic and Health Survey, 2013), whereas fixed-line telephones which were completely destroyed during the civil wars are used by less than 1% of the population (CIA, 2014).

Concerning internet access in the wider geographic scope, Liberia still has a weak communication infrastructure without an advanced submarine cable connecting with neighboring and foreign countries. Without this advanced technology, internet access is very limited to a small territory with high service costs, $140 per month. With the exception of governmental agencies in Monrovia, the high cost of internet access has undermined communication traffic to exchange and share recent information among people. Especially, communication with rural areas was more challenging because most government branch offices of the county level do not have adequate internet accessibility.

4.1.5 Social and cultural norms

Traditions are hard to be changed. Changing public behavior requires social learning and mutual acceptance of new solutions between response teams and Liberian citizens deeply committed to social and cultural norms (Abramowitz et al., 2017). Personal networks based on communal trust are very important in the Liberian society. This social and cultural context is also shared with neighboring countries, Guinea and Sierra Leone. When Liberia suffered through two violent civil wars, thousands of refugees from Libera fled to Guinea and Sierra Leone. Those refugees mostly settled down along the international border where UNHCR supported them with humanitarian assistance. After the civil wars ended, lots of Liberian refugees did not return to Liberia, but settled down in Guinea and Sierra Leone (Sawe, 2018). This context has caused many to move across borders not only to visit family, friends, and relatives among the three countries, but also to look for food and necessities for daily life. Recent studies estimate that population mobility across this region is seven times higher than any other countries in the world (WHO, 2015).

Deeply embedded in this region is a compassionate culture. People employ lots of hugging and kissing to express their affection to one another. These cultural norms and behaviors are

also presented at traditional burial practices. In adherence to ancestral worship rituals, people in Liberia strongly believe that family members and friends who passed away become ancestors to take care of their welfare (Dubois et al., 2015). Therefore, they carefully carry burial procedures from collecting, washing corpses to touching, kissing, and staying with the corpses for several days to show their respect and honor their deceased loved ones.

4.2 Late March 2014: The Ebola Virus as External Turbulence

A fatality caused by an unfamiliar infection in Guinea in December 2013 was suspected as an Ebola virus, but that infection was not confirmed as the Ebola virus until early March 2014 (Baize et al., 2014). The first cases in Liberia was reported on March 30, 2014 from Lofa and Margibi counties which share the border with Guinea (Dahn, 2014). Ebola virus disease (EVD), formerly known as Ebola haemorrhagic fever, spreads from wild animals to humans or human to human through bodily fluids such as: urine, saliva, sweat, feces, vomit, breast milk, and semen. While the Ebola virus is typically contracted through direct contact with the bodily fluids of an infected person, it is also possible to contract the virus by touching other objects that transfer the infected bodily fluids to another person. The Ebola virus has a latent period of 21 days before showing particular symptoms including fever, vomiting, and bleeding. For example, when an infected person who is still in a latent period takes a bus, this person touches handles and seats. People in the same bus might touch the handles and seats which the infected person touched, and they may be exposed to the Ebola virus. This virus has a strong potential to spread without limits or notice through public places if these affected people move within the 21 day latent period. One case detected in a community indicates many other affected cases in the same and, possibly, neighboring communities. Once the symptoms were confirmed as the Ebola virus, the chance of survival of confirmed cases is between 20-50%. Only an

immediate response with quality medical care plays a critical role in increasing the chance of survival (CDC, 2018).

Due to easy transmission through direct or indirect contacts and fast progress after a slow-onset of symptoms among a group of people or communities, the whole response requires an effective and efficient resource management system. First, the accurate surveillance system increases the predictability of the future resource demands while preventing further spread. Second, the whole response should have enough inventory to support the entire community even if there is only one case reported. Third, those resources need to immediately be distributed to the affected communities while quickly quarantine and treat the affected cases. In other words, the performance of a relief logistics network plays a central role in increasing the entire response operations in response to an Ebola outbreak.

4.3 April to August 2014: The System Emergence in Response to the Ebola Crisis

This section illustrates how the existing system constituted with different institutional contexts reacting to the external turbulence, the Ebola virus, and how those reactions created a new system in response to this external turbulence. This period was the most chaotic time to figure out without international assistance what to do in response to an unprecedented crisis. Particularly, this period created important environmental conditions where a relief logistics network was set up under the international response framework in mid-August when the situation already turned ‘out of control’. Understanding the process of the system emergence helps policy makers to identify and prioritize criteria of coordination goals and strategies to increase the system performance while overcoming situational challenges.

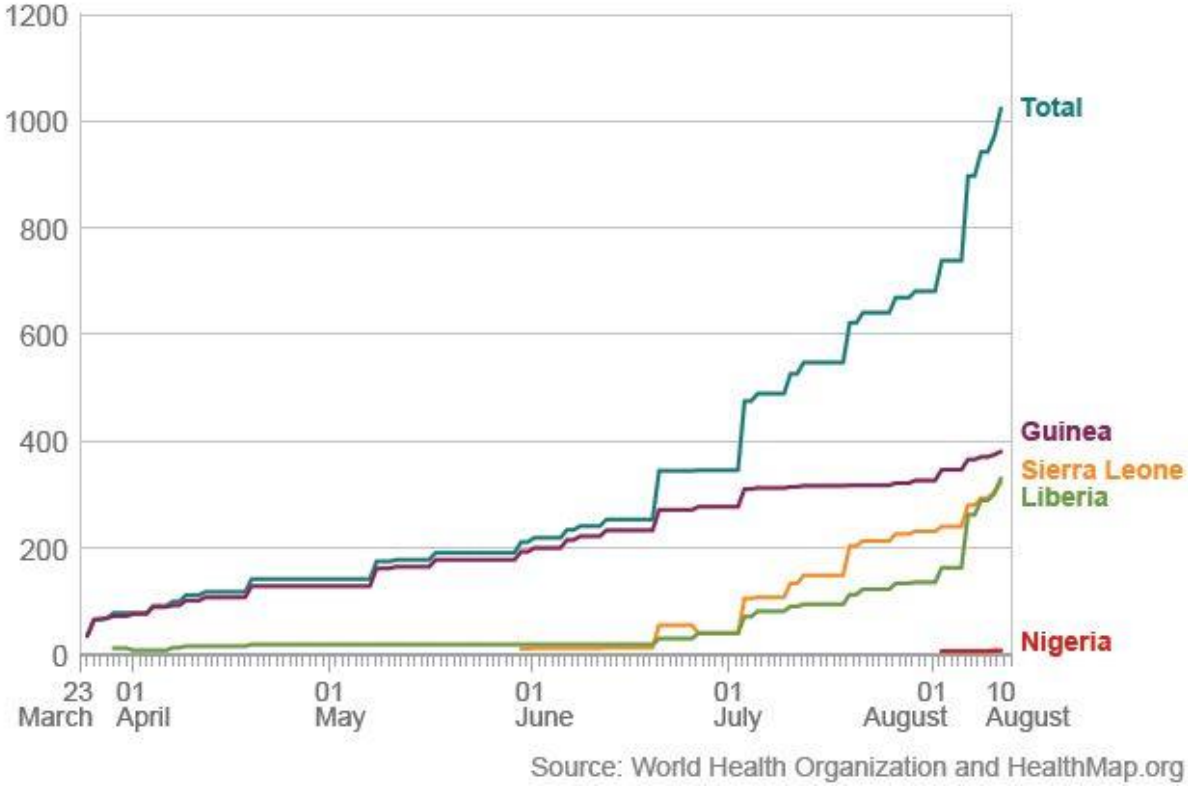


Figure 7 Ebola Cases in West Africa from April to August 2014

(Referred from BBC, 2014c)

4.3.1 Environmental context

When the Ebola virus started, a widespread, rainy season also started. Many parts of the country became swamps. Lots of unpaved roads connecting to rural areas became so muddy that any vehicle could not pass through those areas. This aquatic environment created a very favorable condition for the Ebola virus to spread through river and ground water.

4.3.2 Government system

4.3.2.1 International government situation

When the Ebola virus was categorized as an epidemic outbreak in Guinea in early March, the World Health Organization (WHO) took the lead in coordinating the response to

the situation. Other major humanitarian aid agencies like the United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA) did not actively respond to WHO's warning, because those agencies did not have experts and experience in response to an epidemic situation (ODI, 2015). However, the international health governance system led by WHO did not have strong enough leadership to declare an international call by itself. Meanwhile, the Ebola outbreak placed demands on the organizations that were more than 10 times greater than ever experienced in the almost 70-year history, whereas there were no funds reserved for emergency outbreaks (Wenham, 2016).

The WHO's African Regional Office (AFRO) was tasked with keeping abreast of the development of the Ebola outbreak. The surveillance of this international epidemic crisis failed in part because the appearance of Ebola in West Africa was unprecedented and early cases were often confused with Lassa fever (McInnes, 2016). In late March 2014, the AFRO had convened an emergency teleconference to report the high number of suspected cases and deaths in Guinea and notified the high possibility of cross-border transmission to neighboring countries. AFRO secretariat advocated that the regional director declared an internal WHO grade 2 emergency which claims the needs of moderate international WHO response intervention (WHO, 2014). AFRO secretariat also established a regional emergency support team to coordinate technical and operational support.

However, by May 4 2014, the WHO secretariat in Geneva had deployed almost 90 staff members to Guinea whereas only 20 staff members were sent to Liberia and only one person was dispatched to Sierra Leone, even though an increasing number of cases had been reported in Liberia and Sierra Leone (Nunes, 2016). The disproportionate number of staff members deployed to Guinea reveals that the information and concern of the cross-border transmission by AFRO office were not sufficiently communicated to the WHO central office. This resulted in a lack of consideration of how the outbreak might unfold and spread to affect

neighboring states. On the other hand, AFRO did not recognize WHO's new standard operating procedures (SOPs) for disease outbreaks which advocated the mobilization and deployment of expertise within 72 hours of official notification, because these SOPs were just released in the very same month the outbreak was detected (Kamradt-Scott, 2016; Nunes, 2016). The long history of miscommunication between WHO regional offices and headquarters combined with the recent release of the new SOP caused a critical delay to develop and dispatch investigating groups to affected countries.

4.3.2.2 Domestic governmental situation

During the Ebola crisis, President Ellen Sirleaf Johnson (2006-2018) served as the first female leader of the country. Even with two sequent presidential terms, she did not succeed in improving social development: the unemployment rate was as high as 80% and efforts to rebuild the educational system failed. Particularly damaging were the endless political scandals, such as money exchanges between NGOs who engaged in commercial and noncommercial foreign development projects and the government. Political scandals deepened the public mistrust toward the government and international aid (Jerving, 2014). A survey by the Accountability Lab showed that the word "corruption" was selected as the most representative word the Liberians chose to describe their perception toward the government. Transparency International ranked Liberia 94th among 175 countries in 2014, based on citizens' perception of the public sector (Moran, 2015).

The government established Emergency Operation Center led by the President Sirleaf Johnson among government ministries in response to the Ebola crisis in April with few international partner organizations including CDC, WHO and IFRC (Dahn, 2014b). Even though this outbreak was an unprecedented incident so that no one knew what they needed to do, the Liberian government with international partner organizations on site dealt with the

situation effectively. As of May 2, no new cases had been identified and the first wave of the epidemic was considered over (UNICEF, 2014a). With the end of the first wave, Ebola Task force started to reduce meetings and partner international organizations reduced staff while continuing the training of health professionals to take care of EVD patients and to keep surveillance and prevention operations.

"Somebody is just coughing blood… Then all of a sudden, they gone delirious, nobody knew what it was (Interviewee, 14)."

However, on May 25, new Ebola cases started to be detected when a patient who had contracted EVD in Sierra Leone died in Liberia's Lofa county. Immediately, eleven new suspected cases were generated (UNICEF, 2014b). National Task Force meetings resumed on a daily basis, and EVD burial teams were reactivated (UNICEF, 2014c). On June 17, the first EVD cases were reported in Liberia's densely populated capital, Monrovia. These cases turned a remote, rural Ebola outbreak into an urban wide-spread epidemic (BBC, 2014a). The government developed several policies to deal with the situation. To limit population movement traveling across counties from the epicenter communities, national armies set up check-points at Lofa, Cape Mount, Bomi and Gbarpolu where the Ebola virus came from next to Guinea. Only people who were officially allowed to move to other counties could go across borders after checking their body temperatures. The second policy is to pick up dead bodies. The government set up a call center in Monrovia. The government encouraged community people to report any Ebola suspected cases or dead bodies to the government team so that a national health team would go directly to pick up those cases in reported communities to avoid infecting other people (Kirsch et al., 2017). Eventually, the entire country was shut down to minimize people's movement: no business, no school, and no social gatherings (BBC, 2014b). Everyone needed to be quarantined at home. Even with national response efforts, the national capacity with little support from a few international

organizations ran out to catch up the fast pace of the virus spread without figuring out what to do. Medicins Sans Frontieres (MSF), the only international aid organization in the field, eventually made an international response call in June 2014, saying "The epidemic is out of control" (MSF, 2014b). The President made an international emergency call in July 2014.

> *"But once it spiked, once Ebola started spreading which nobody could afford, not even the ministry, WHO didn't, even assume that wouldn't happen. The moment it's spreading to hit urban population, the ministry ran out (Interviewee, 7)."*

4.3.3 Domestic public health conditions

Due to a high possibility of the Ebola virus to spread any visiting patients in health facilities, the Ebola treatment unit cannot be shared with existing health facilities. In April, the Liberian Ministry of health with support from Médecins Sans Frontières (MSF) established an isolation facility at an old refugee transit facility in the town of Foya, where the first case was found. The Firestone company established a 23-bed unit in April in Margibi county (Reaves, Mabande, Thoroughman, Arwady, & Montgomery, 2014). In Montserrado, Samaritan's Purse, another international NGO in the field, converted a hospital chapel (ELWA1) into an isolation facility. Only MSF and Samaritan's Purse supported ETU operations; MSF was the only experienced organization to deal with the Ebola situation. Since Liberia did not have enough health experts, MSF needed to train people to work as health volunteers in ETUs. At the same time, MSF also needed to learn this new situation in Liberia while working. This situation was far short of health workers. The existing health workers needed to work day and night without rest.

"Even for MSF, they were learning everything…… everyone was trying to catch up constantly (Interviewee, 30)."

"The laboratory technicians are working 24 hours a day (Interviewee, 24)."

In addition to the limited number of ETUs and health workers, such temporary structures of ETUs became the center of spreading Ebola virus. The converted hospital chapel or refugee transit facility did not have appropriate sewage facilities. Without proper protection gowns, health workers working in those ETUs were easily exposed to the bodily fluids of Ebola patients. The isolation unit partitioned with curtains or plastic walls in the ETUs spread the virus to not only other suspected cases quarantined in ETUs but also health workers. As multiple health workers from a foreign NGO were affected, the NGO withdrew from Liberia, and management of the second ETU (ELWA2) was transferred to MSF and the Liberian government (Nyenswah et al., 2014).

"….the buildings in which the current ETUs were regular hospitals and church buildings…even though they had separated them (Ebola affected cases), it was just by a sheet and contamination still came through the flooring…(everyone was) exposed to swabs or bandages or blood on the floor……That's how most people got it once they went into you" (Interviewee, 7)

"When I went I saw the government ETU workers they don't have anything. They only have gloves and apron and then taking a body here and there…" (Interviewee, 25).

While these poor working conditions caused many health workers to be infected by the Ebola virus, this shortage of health capacity was impossible to receive all patients. By the end

of July 2014, the country faced a crisis as the ETUs were filled beyond capacity, and Ebola patients quarantined in ETUs fled away and hid in forests. Ebola patients were dying on city streets, in their homes and hiding places (Nyenswah et al., 2016). Dead bodies on the street in a heavy rainy season became another channel of the Ebola virus to spread without limits.

Meanwhile, the policies aimed to prevent Ebola spread to the general public in communities. The movement policy enforced in July unexpectedly exacerbated the food and water shortage in Liberia by limiting the mobility of people within Liberia and to neighboring countries. As a result of the travel restrictions, approximately 4.1 million Liberians suffered from a lack of access to nutritious food and economic opportunities. Out of desperation, many people secretly traveled long distances to try to find clean water or bags of wheat or flour to feed their families and many kids. More than 85% of families have been forced to eat fewer meals, even as low as just one meal a day (WHO, 2015). As a result, the entire public health condition became worse than before while increasing the vulnerability to the Ebola virus with weaker immune conditions of the population. Water is a critical resource to maintaining sanitary conditions which prevents the spread of the Ebola virus. Since most public toilets do not have water to flush and wash hands, this poor condition has undermined people's regular habit of washing hands, which increased the individual vulnerability of the Ebola virus (USAID, 2016).

4.3.4 Technical infrastructure conditions

A radio service played a major role in providing updated situations and necessary information to the public. Through radio programs, the government announced a national call center number to request pick-up services for affected cases in community. A national call center got lots of calls from different communities. However, the very shortage of ambulances with non-passable condition of roads failed to meet those demands to provide help.

"As we listened to the radio and heard what the ministry of health was saying…We did that for a couple of weeks but things kept deteriorating. More people were getting affected. People were panicking and running out of the community (Interviewee 24)."

"I remember when we started Ebola 2014 around April to June, July, I think we only had two ambulances. Two ambulances for the entire country (Interviewee 6)."

4.3.5 Social and cultural norms

Social and cultural norms play a central role in guiding people's behaviors. Facing all these external challenges, people do not perceive surrounding environments and situations as objective information. Rather, people actively interpret the meaning of those environmental and situational contexts based on their beliefs, norms and previous experiences. This whole process guides how to respond to the environment and what to do. This section illustrates how people reacted to an unprecedented environment which the Ebola virus created based on social and cultural norms.

4.3.5.1 International context

Liberia is geographically isolated from the Western world. Liberia has experienced repeated public health crises which were exacerbated by poor economic and social conditions International health organizations may have been slower to react to the Ebola outbreak due to the frequency of public health crises in Liberia. Due to the geographic distance and ignorance about Liberian culture, the Western media framed this Ebola crisis as a product of backward practices such as bushmeat consumption and a black-market monkey trade. In the end, this

information turned out to be wrong. However, this negative framing of the Ebola crisis made the western world perceive the Ebola crisis as the destiny of African countries caused by primitive and uncivilized behaviors, which undermined collective action efforts to deal with the crisis (Nunes, 2016; Wenham, 2016).

This international negligence lasted until an affected case was found among U.S health workers who worked in Liberia in the late July 2014. This case drove a worldwide attention because it showed that this Ebola virus could spread to the Western world, which ignited a public health emergency of international concern (PHEIC) on August 8th 2014. When this infected health worker returned to U.S to receive treatment, U.S. government immediately set up a surveillance system to contain the disease. The world leaders queued up to express their concern, offer aid, and in a limited number of cases, to dispatch troops to assist in the humanitarian aid effort (McInnes, 2016).

4.3.5.2 Domestic context

Since December 2013, lots of people, including family members, relatives, and friends had died all of sudden in communities. People assumed that those dead people were affected by yellow fevers, malaria, diarrhea, or tuberculosis which showed the similar symptoms. Unlike the spreading patterns of those illness, a group of people started to die. People were said this ‘mystery’ disease was the result of one’s misconduct (Omidian, Tehoungue, & Monger, 2014). In late July, the Liberia government with US Centers for Disease Control and Prevention (CDC), WHO, and other partners set up an Incident Management System (IMS) (Pillai et al., 2014). The IMS concentrated efforts to inform the public about on-going situations and announced preventive actions for this disease such as no touch to any suspected people or dead bodies. The IMS tried to increase efforts 1) to strengthen a surveillance system to investigate cases and patterns of spread, 2) to isolate and treat patients with laboratory tests to confirm

cases and 3) to safely bury dead bodies from the Ebola virus. Nevertheless, those policies could not work effectively because of shortage of trained staff and resources, poor internet and mobile phone coverages, and limited transportation means with worsening road conditions (Nyenswah et al., 2016). Meanwhile, most of the public did not trust the public information due to accumulated mistrust toward the government. Ignoring the warnings, people started to have frequent travel to visit their families' and friends' funerals to express their honor to those dead bodies. This burial practice for Ebola-affected dead bodies turned out to be a major cause to rapidly spread the Ebola virus over this region in the initial stage of the Ebola crisis (WHO, 2015).

"The ministry of health is lying. There's no such thing as Ebola. There was that disbelief grown by the media. Because of that disbelief, people weren't listening to the health advice (Interviewee 3)."

When the situation became worse, people started to make a call to request an ambulance to pick up affected cases. Some people went to ETUs to be quarantined. However, the ambulances would not reach the community and people died. Those people who left for ETUs never came back to the community. This repeated policy failures even more increased the public mistrust with fear about ETUs and rage toward the government. This strong mistrust caused the public suspicion and rumors about governmental response operations in communities. Community people started to believe that the Ebola virus was created by the government or by foreign development organizations (Jerving, 2014; Omidian et al, 2015). Eventually, people started to attack health workers in ETUs and turned away from the government health system.

"There was a conspiracy theory from some communities…All Ebola was some experiments from international community and some Western countries…… Some health workers were also attacked (Interviewee 6)."

"When someone is sick and then they (foreign health workers) prosecute that illness to the emergency unit…When they take sick people, they're not going to come back alive…it created that enmity (Interviewee 27)."

Community people went to see secondary healthcare providers, like spiritual healers, and hid from the government to avoid being quarantined at ETUs. Since those secondary healthcare providers neither have proper medical knowledge nor medical protective gowns and equipment, they exposed themselves to be contaminated by the unprecedented Ebola virus (Patrick, 2017), and they became the central location to spread the virus to community residents who visited for any health issues.

"People (Spiritual healers) treated and our people got one of the largest forests in Liberia… They treated people in the forest, almost every sickness they think they got a solution to it.....They're afraid of all the ETUs here" (Interviewee, 24)

4.4 September to December 2014: Emergence of a Unified Coordination System in Liberia

After MSF's urgent call for extra resources to support the operations in the middle of August (MSF, 2014) WHO announced a roadmap in response to the Ebola crisis on August 27th. However, in early September, UN agencies set up a new leadership called United Nations

Mission for Ebola Emergency Response (UNMEER). International leading organizations and the UNMEER developed a response plan for the West Africa region in Accra, Ghana until the middle of September (ODI, 2015). Meanwhile, the Liberia national government and major participating organizations already established a unified emergency operational center (EOC) and started response operations before the UNMEER came into Liberia. After the official declarations of international emergency call, the response approach was dynamically changed with a full support of human and physical resources.

> *"After August, when the Ebola crisis was declared a public health emergency international declaration, we started getting a lot of support…both human resources, material and financial that we required to effectively support the outbreak response (Interviewee, 9)."*

The international emergency call drew lots of international organizations with resources into Liberia. Ironically, even with the surge of resources, the number of Ebola affected cases even more dramatically increased from late August, shown below in Figure 8.

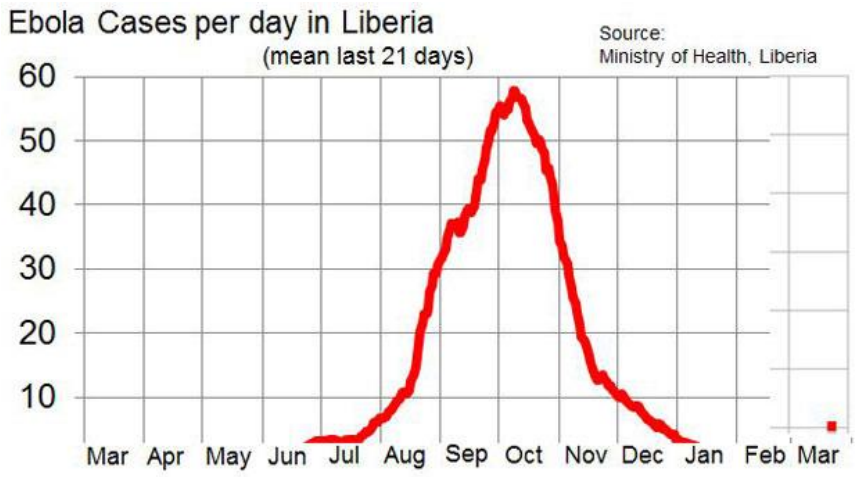


Figure 8 Ebola Cases Per Day in Liberia

Even though major problems of the Ebola crisis from March to early August in Liberia was attributed to a shortage of medical resources, once international expertise and resources entered into Liberia, the Ebola crisis turned into a coordination crisis to manage human and physical

resources. William Vannier who served as a supply chain director at Medecins Sans Frontieres (MSF) during the Ebola crisis in Liberia said that "We often said at that time that the Ebola response was not primarily a medical response but more about logistics and supplies" (Paterson & Widner, 2017, p.2). Most of participating organizations did not have expertise and operations in response to an epidemic crisis. Unfamiliar with Liberia context, all participating organizations faced coordination challenges in terms of 1) which organizations would serve what tasks with whom, 2) how to develop connections among participating organizations which enhance the efficient transmission of resources, and 3) how to identify and engage critical organizations and operational levels in a coordination process to increase information flows. The system performance to decrease Ebola affected cases was substantially determined by the speed of dealing with these challenges interacting with surrounding physical and institutional environments in a coordination process.

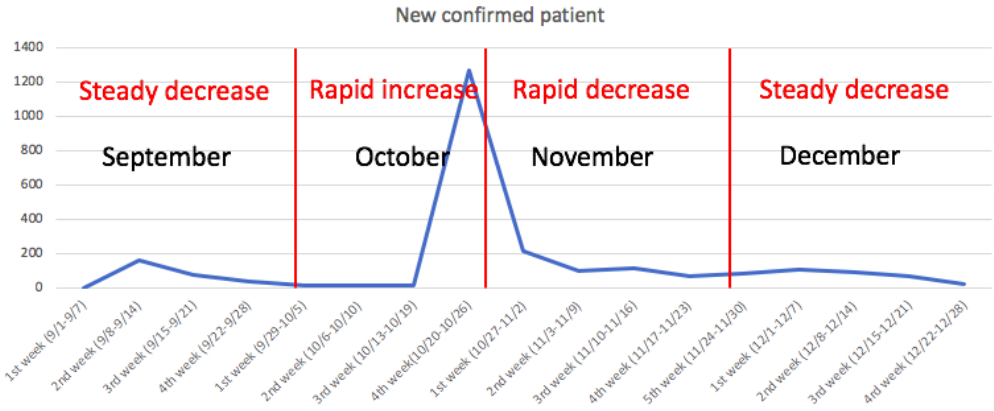


Figure 9 New Confirmed Cases Per Week From September To December 2014

(Data from WHO)

Figure 9 shows weekly new confirmed cases from September to December 2014. Even though September showed a rapid increase of newly confirmed cases compared to previous months in the graph 4-2, September had the steadily decreasing number of newly confirmed cases in the graph 4-3. Over the second and third weeks of October, the number of affected cases rapidly increased to the peak. In the last week of October, the number of affected cases

sharply decreased, continuing the decreasing trend until the end of December. Focusing on this four-month period showing dynamic changes of the number of affected cases, this study investigates how participating organizations have solved three challenges in a coordination process interacting with physical and institutional environments.

4.5 Conclusion: What's next?

The consequence of a disaster is not determined by an incident itself, but by institutional contexts which could increase or decrease the impact of the incident. Given that the Ebola outbreak started as a local public health incident in a small community in Liberia, it is also very important to understand environmental factors reacting and interacting with the Ebola virus and its response operation. The series of long-term civil conflicts were the critical factor to explain the weakness of economic, health and social capacities with marginal conditions of physical infrastructure, which served as the fundamental support of the Ebola response operations (Moran, 2015). The WHO's weak organizational leadership and the western world's cultural bias and perception toward the African region failed to immediately respond to the Ebola crisis in the West Africa. The time-critical Ebola epidemic situation had been rapidly degraded out of control with little resources without international collective action for eight months after the first Ebola suspicious case was reported in Guinea in December 2013 (Baize et al., 2014). Particularly, the interdependent effects between poor health and logistics infrastructure challenged rapid medical interventions by delaying movements of human resources and medical supplies in Ebola affected communities. The strong opposition of the public toward the government and international aid organizations and limited communication means between the government and the public created another challenge for the Liberian national authority to engage citizens' cooperation in avoiding the Ebola virus spread.

Under this complex environment, finally, the international response system was established in Liberia. This establishment also brought a change to this degrading situation, which created new complexities interacting with existing formal and informal contextual factors. While adopting to the existing environment and filling the huge gap of resources, the international response system should figure out how to procure, manage and deliver resources in an efficient manner and to engage the citizens to follow health guidance. The coordination in a relief logistics network serves a critical part to minimize the consequences of the Ebola crisis in Liberia. Following sections analyze how participating organizations coordinate to develop effective system to decrease the Ebola consequences while overcoming existing challenges over the response periods.

5.0 The Evolving Trend of Organizational Propensity in Creating Partnerships

This chapter highlights a micro perspective of the network evolution by analyzing organizations' particular strategies in creating partnerships, which ultimately aims to increase individual organizational performances. To be specific, this chapter seeks to discover the changes of organizational behavioral propensities to develop partnerships over time. Each organization follows both self-existing and circumstantial rules which are prescribed for certain behaviors in particular circumstances. These organizational behavioral changes caused by these rules lead capacity changes of the system in response to environmental changes. This adapted system, in turn, generates new rules for participating organizations to follow. The new rules to follow in a changing environment are determined by the variations and diversities of the participating organizations in a network. If a large number of organizations that have diverse attributes participate in the network, the features of network structures become more complex due to higher chances to develop a wider range of new combinations of partnerships. As a complex adaptive system, the 2014 Ebola relief logistic coordination network consists of diverse organizations that interact within a network. Each organization tries to increase the success of partnerships which contribute to promoting both individual and collective performances. The following part introduces 1) collective action dilemma in creating a partnership, 2) organizational attributes as predictors to create strategic partnerships, 3) data analysis and results, and 4) summary and conclusion.

5.1 Collective Action Dilemma in Creating a Partnership

Organizations that face the same problem create collaborative networks to increase their capacity to solve common problems effectively and efficiently. These participating organizations make efforts to create or discover solutions within a given set of constraints, including knowledge, time, resources, and even competition (Agranoff & McGuire, 2003). This collaborative network created by a voluntary mechanism offers several potential advantages over formal decision-making structure. This network can exercise a higher discretion to deal with the problem by creating new rules or modifying existing rules in response to a certain situation through the common agreement among the participating organizations. In this rule creating and modifying process, the participating organizations try to make collaborative work to achieve the common goal while trying to keep their own authority and to achieve organizational goals through negotiation. This collaborative network serves a significant role in finding better policies or improving policy outcomes by mitigating collective action problems as well as capturing a greater advantage from collaborative problem solving (Agranoff & McGuire, 2003; Lubell et al., 2016; Provan & Milward, 2001).

To create this collective action, participating organizations need to pay extra effort to reach common agreements, because the participating organizations have asymmetrical information. Those organizations need to deal with transaction costs, including information search, bargaining and negotiation, enforcement costs and risk, including coordination, division, and defection issues (Feiock, 2009; Gerber, Henry, & Lubell, 2013; Maser, 1998). The participating organizations are not willing to participate in a collective action unless a benefit from the action is higher than those costs and risks. In other words, collective actions are expected to arise when potential benefits exceed the transaction costs of negotiating, monitoring, and enforcing an agreement. Furthermore, the participating organizations'

opportunistic free-riding behaviors, uncertainty about other organizations' trustworthiness, and the uneven distribution of costs and benefits over time can challenge the organizational collective actions (Feiock, Steinacker, & Park, 2009).

Recently, several studies started to investigate organizational strategies to minimize transaction costs to find appropriate partners based on organizational similarities sharing the same organizational attributes. To be specific, those studies explore the impact of same organizational attributes as a cue of collaborative security, such as geographical and socio-demographical attributes, on interacting patterns among organizations in a collaborative network (Atouba & Shumate, 2015; Gerber et al., 2013; Song, Park, & Jung, 2018). The contexts of those inter-organizational collaborative networks investigated by these recent studies were relatively stable and predictable. Also, the participating organizations in those investigated collaborative networks were already familiar with one another because they worked in the same or nearby places for a long term (Song et al., 2018), or previously worked together to deal with other issues (Atouba & Shumate, 2015). This familiarity among organizations allowed their partnerships more predictable within a limited pool of participating organizations. The impacts of those organizational attributes on creating partnerships are quite obvious.

In contrast, the 2014 Ebola relief logistic coordination network in this research existed in greatly uncertain situations with unpredictability of changing environments and the least amount of information about participating organizations in a network. Because the situation kept changing in an unpredictable way, the participating organizations in a network predicted neither what kinds of tasks they would serve for how long nor what kinds of organizations would join or exit the network in the next month. Participating organizations needed to take a higher risk to find appropriate partners than in a relatively stable environment. This research argues that organizational similarities based on organizational attributes will play a critical role

for the participating organizations in the Ebola relief logistics network to minimize transaction costs in creating a partnership. Concerning the rapid changeable situations over a long period, this research argues the effectiveness of the different types of organizational attributes on creating a partnership will change over time. The next section will introduce specific organizational attributes and their impact on creating organizational partnerships.

5.2 Organizational Homophily Propensity to Create Partnerships

That two actors sharing similar attributes in a network have a higher probability of a connection between them, which is called a homophily propensity, which was one of the first features noted by an early social structural study (Freeman, 1996). In a process when organizations look for partners with limited information about other organizations, those organizations assess other organizations using physical and conceptual proximities (Axelrod & Cohen, 1999) that characterize organizational attributes. The physical proximity indicates a physical distance among organizations. The conceptual proximity indicates an institutional dimension perceived or assumed among participating organizations. This conceptual location could be either explicitly or implicitly agreed upon based on organizational categories in the field of international collaboration (Axelrod, 1984).

This research pointed out that organizational attributes are not fixed characteristics; rather, organizations could be re-defined when time and proximity changes. In a context of the Ebola relief logistic network, participating organizations obtained new organizational attributes after joining the network in addition to their existing attributes. This research suggests how new organizational attributes can be identified after joining the Ebola relief logistics network. Before organizations participated in the Ebola relief logistics coordination network, each one positions in physical and conceptual spaces: 1) physically located in a

certain region of the world and 2) conceptually categorized in a certain organizational tier. After those organizations participated into the network, they get new organizational attributes based on 3) which operational level they work (physical location) and 4) a organizational role to serve (conceptual location) in the network. When Ebola occurred in Liberia as an unprecedented epidemic situation, participating organizations needed to figure out individual organizations' roles and their operational levels through a coordination process in the network.

Table 6 Organizational Existing and New Attributes

	Physical Space	**Conceptual Space**
Existing attributes	Regional location	Organizational tier
New attributes	Operational location	Organizational role

5.2.1 Physical space: Regional location Vs. Operational level

The fundamental source of homophily propensity is space; the closer people are physically, the higher the chances are that they will work with together, compared to working with organizations far away. The law of proximity influences the choice to form relationships with other organizations in the same region (Allen, 1977; Krackhardt, 1994), because the geographical proximity decreases the cost of cooperation and coordination compared to the coordination with other organizations in a far distance (McPherson et al., 2001). Indeed, the regional location increases the opportunities for organizations to observe and learn more about one another, thereby creating conditions conductive to the development of communication ties. Organizational knowledge flows tend to be localized because searching for local information could be less costly than searching for global information (Rosenkopf & Almeida, 2003).

Geographic proximity also implies the sharing of the common social and cultural environments among neighboring organizations (Rivera, Soderstrom, & Uzzi, 2010; Romanelli & Tushman, 1986). Global regionalization increases the trends to create socially constructed

and politically contested clusters by economic, political, geographical, security, and social projects (Hettne, 2005). Organizations located in the same economic or political clusters have much more chances to communicate and cooperate to achieve the common goal in an ordinary time. Sharing communal cooperation experiences help them to learn and model behavior from similarly situated peers and engage in repeated interactions, making participating organizations familiar with one another and strengthen their ties (Gerber et al., 2013). In this reason, when organizations just joined in the Ebola relief logistics network, an organizational regional location would serve as a critical organizational attribute for organizations to seek new partners out of multiple unfamiliar organizations from all over the world.

After joining a network like the Ebola relief logistic coordination network, the participating organizations are assigned to a certain operational level to serve their tasks during an operational period. Those organizations need contextual information for them to successfully adapt to a new environment. Working with other organizations assigned to the same operational level allows those organizations with more chances to meet in person and exchange timely information and resources. In-person coordination meetings also provide more information about other organizations concerning what kinds of resources they have and how well they perform. Particularly in a highly uncertain situation, neighboring organizations that show a good performance would become a role model for other neighboring organizations (Atouba & Shumate, 2015). When they join in a multi-layered collaborative network, they need new partners that share a collective goal in the same operational level.

When the organizations join into an international collaboration such as the Ebola crisis response operations, their working locations and environments are changed. In the early stage to join in a new collaboration network, the participating organizations will show a strong propensity to be connected with the other organizations that come from the same regional locations to avoid transaction costs and risks. However, while working throughout the

operational period, the participating organizations get more familiar with other participating organizations that work at the same operational level and to particular needs of that assigned operational level. In this reason, the organizations will show stronger homophily propensity based on an operational level in the later stage of the operation.

Assumption 1. The homophily effects of the regional location will decrease over time.

Assumption 2. The homophily effects of the operational level will increase over time.

5.2.2 Conceptual space: Organizational tier Vs. Organizational role

Organizational institutional arrangements define specific rules about how the negotiation and bargaining process for collective outcomes should be organized, how different incidences and responsibilities should be allocated among participants, and how agreed upon rules will be implemented and enforced (Steinacker, 2004). These specific rules help to minimize collective action problems caused by individual organizational misbehaviors while increasing advantages to improve individual and collaborative performances (Agranoff & McGuire, 2003; Lubell, Feiock, & Ramirez, 2005; Provan & Milward, 2001). Working across a different type of organizational institutional arrangement causes extra costs to drive a collaboration, because multiple organizations require bargaining and negotiating processes over different policies and to enforce and monitor any resulting policies (Feiock, 2009; Maser, 1998). A certain type of organizational institutional arrangement can be an attractive or adverse factor to work with.

This research argues that the organizational tier would play an important role in finding partner organizations in uncertainty. The organizational tier is defined as the standing or position of an organization in relation to other organizations in a stratification system based on legitimacy, recognition, or esteem (Podolny & Phillips, 1996). To enhance one's survival through cooperation with appropriate partners, people identify and categorize others into in-

groups or out-groups organizations to deal with a particular issue (Simon, 1976: 72). The organizational tier in this research indicates the existing condition to determine the extent of influential power that an organization exercises over a decision-making process. One's extent of influential power causes a different time span in making and implementing a decision. The upper layers of such systems typically involve processes that span longer time intervals, while the lower levels are more often involved with processes that run relatively quickly (Simon, 1981).

In a context of international collaboration system in response to a global issue, This research suggests five different organizational tier. A global-tier organization has played a leading role in a decision-making process to solve international problems. As a global-tier organization needs to deal with international issues, its decision-making processes are much slower because the coverage of its operational plan and executing budget are more complex and bigger compared to other tiers of organizations. Global-tier organizations like the United Nations agencies share similar institutional processes to deal with global issues. The institutional structure of regional-tier and national-tier organizations, like the European Union and a state respectively, are simpler than the global-tier organization organizations. Because those organizations only focus on increasing their regional and national interests exclusively, their decision-making process are relatively shorter than the global-tier organizations. As major donors to support the global- tier organizations, they directly or indirectly influence decision making process to develop international policies contributing to their regions and countries' interests.

Private-tier organizations such as private companies have much flatter decision making systems. To increase efficiency to follow a rapid life cycle of industrial and market changes, private-tier organizations keep quick decision-making processes even though their organizational sizes and budgets are big. The private-tier organizations have a big potential to

quickly mobilize substantial resources, such as financial and physical resources and specialized skills. Recently, international organizations have driven to create private collaboration in response to global issues (Rumney, 2016), which provides indirect channels to influence international decision makers for a global issue. Nonprofit-tier organizations including non-governmental organizations have the flattest organizational structure among all tier organizations, because the size of the organizations are, in general, much smaller and organizational goals are much simpler and straightforward. This tier group of organizations hardly exercises influence over a decision-making process on a global issue because those organizations usually participate in policy implementation in a field decided by their donors with allocated budgets assigned to certain tasks.

In the field, the organizations' efforts to reduce the risks of collaborative failure and to maximize the chances of collaborative success play a key role in creating a successful collective action. When organizations serve the same mission, interests, and tasks, this perceived similarity provides inducement and opportunities to form collaborative ties and help to reduce the risks of collaborative failure (Atouba & Shumate, 2010). Those organizations that serve similar tasks often create a working cluster to enlarge their capacities by sharing resources and skills. Participating organizations seek benefits from working clusters. First, a working cluster allows a newcomer to have a chance to meet existing and new incoming organizations (Axelrod & Hamilton, 1981). Without this smaller coordination group, the newcomers would be a negligible part of the whole environment, consisting of a number of existing organizations. Second, participating organizations in a cluster have better access to complimentary resources, such as human resources, public institutions and specialized information, complementary products and services, and better management systems, to support individual and cluster tasks (Patti, 2006). By collecting organizations that have similar

expertise, a cluster strengthens its robustness to failure while diversifying resources and skillsets to serve tasks from participating organizations.

The relief logistics coordination network requires six types of roles: response coordinator, logistics service providers, donors, armies, field operators, telecommunication supporter (Kovács & Spens, 2008; Schiffling, 2013), and other services if necessary. Right after entering into the Ebola relief logistics network, organizations did not know what kinds of role they would serve in response to the Ebola crisis. When they just arrived in the field. Under an uncertain situation, an organizational tier would be recognized as a significant predictor to create collaborative partnerships because their similar decision making structures and influential power would reduce conflicts in a decision making process (Rivera et al., 2010). To avoid those transaction costs in the collaboration, they would expect higher efficiency in developing a collective action.

However, during the coordination process in the field, most participating organizations were assigned to certain missions and tasks which would not be fulfilled with the regular organizational operating manners. Since their missions and tasks were changed in response to a new environment, those organizations needed to set up new coordination process adapting to the new environments. The organizations assigned to the same role required heavy coordination to develop a common operational picture, share and manage collective resources, and figure out who is going to serve what in detail. The impact of the same organizational role will have a stronger homophily effect, while decreasing the impact of the organizational tier on creating partnerships over the operational period.

Assumption 3. The homophily effects of the organizational tier will decrease over time.

Assumption 4. The homophily effects of the organizational role will increase over time.

5.3 Data Analysis and Results

5.3.1 Descriptive analysis

Tables from 6 to 9 summarize the changes of participating organizations in each month: the number and organizational attributes. The first four tables show organizational existing attributes before joining the Ebola relief logistics coordination network: organizational regional location and organizational tier. The last four tables show organizational new attributes after joining the network: organizational operational location and organizational role.

5.3.1.1 Organizational existing attributes

In September, the biggest participating regions in the Ebola relief logistic coordination network were North America (48) and Africa region (40). Concerning the organizational tier, nonprofit-tier organizations (55) actively participated into the network, and the similar number of global-tier (32) and national-tier (29) organizations joined into the network. In October, the entire number of participating organizations increased. While the organizations from North America (53) and Africa (49) regions were still major participants, the number of organizations from Europe visibly increased. The nonprofit- (76) and national- tier (46) organizations formed a major part of the participating organizations. In November, the Ebola relief logistics network had the biggest number of participating organizations being added by one-hundred organizations. Particularly, the organizations from the African (77) and European (66) regions rapidly increased; these two regional organizations became the biggest contributors, while the organizations from North America (60) still took a major portion in the network. The biggest increase from nonprofit- (101) and national-tier (84) organizations contributed to the increasing number of participating organizations.

Table 7 Descriptive Information of Organizational Existing Attributes in September

September/Ex.	Global	Regional	National	Private	Nonprofit	Sum
International	14	2	0	0	0	16
Africa	3	4	13	3	17	40
Europe	8	2	3	3	9	25
N. America	7	1	9	3	28	48
Others	0	0	4	2	1	7
Sum	32	9	29	11	55	136

Table 8 Descriptive Information of Organizational Existing Attributes in October

October/Ex.	Global	Regional	National	Private	Nonprofit	Sum
International	15	4	0	1	4	24
Africa	1	4	17	2	25	49
Europe	6	4	12	3	13	38
N. America	6	0	8	9	30	53
Others	0	0	9	1	4	14
Sum	28	12	46	16	76	178

Table 9 Descriptive Information of Organizational Existing Attributes in November

November/Ex.	Global	Regional	National	Private	Nonprofit	Sum
International	29	1	0	1	8	39
Africa	1	8	26	2	40	77
Europe	7	7	29	6	14	63
N. America	7	0	7	13	33	60
Others	0	0	21	3	6	30
Sum	44	16	84	25	101	270

Table 10 Descriptive Information of Organizational Existing Attributes in December

December/Ex.	Global	Regional	National	Private	Nonprofit	Sum
International	19	0	0	0	8	27
Africa	0	6	13	6	34	59
Europe	4	4	9	8	7	32
N. America	7	0	3	10	22	42
Others	0	0	5	4	2	11
Sum	30	10	30	28	73	171

In December, the number of participating organizations decreased unto the similar size to the October network. The organizations from Africa region (59) played a major contributing role with ones from North America (42) and European regions (32). Even though the number of nonprofit-tier organizations substantially decreased between November and December, they still made a large portion of the network (73). The national-tier organizations decreased unto 30 participating organizations between November and December. As a result of a steady increase, private tier-organizations (28) also took a major portion of the participating organizations.

Over the operational periods, there were big fluctuations in terms of number of participating organizations. Particularly, the numbers of the nonprofit- and national- tier organizations greatly fluctuated. The numbers of global- and regional tier organizations were very steady over the operational period. Only private-tier organizations showed a steady increase over the time. However, in terms of regional proportion of participating organizations, the organizations from African and North America continents steadily took a major portion in the network.

5.3.1.2 Organizational new attributes

In September, the majority of participating organizations worked on the international and national operational levels. Almost a half of participating organizations play a role as a donor (62), coordinator (25) and logistic service provider (24). While most donors (55) and logistic service organizations (17) worked at the international level, the majority of coordinators (20) set up a coordination meeting at a national level. In October, the number of participating organizations increased in every operational level; the international (101) and national (33) operational levels had major portions of participating organizations in the network. The biggest number of organizations participated in the network as donors (77).

Meanwhile, the logistics service in the network was greatly strengthened as logistics service organizations (55) increased by double. A communication service role appeared as a new organizational task in the network. As in the September network, most donors (55) and logistics service organizations (17) worked at the international level. The November network had the largest number of organizations in the network. The biggest increase in number was on the international level (172). Interestingly, the county operational level became the second major level as the number of participating organizations increased by double (40), whereas the national (34) and community (24) levels had steady numbers of participating organizations as before. In December when the number of participating organizations rapidly decreased, this big decrease was caused by international and community levels, whereas national and county levels kept a steady number of participating organizations. Next to the international level, the county level was a major operational level. The big portion of participating organizations played roles as donors (55) and logistic service (38). The number of organizations who participated in communication service and healthcare (ETU) providers steadily increased to 19 and 21, respectively.

Table 11 Descriptive Information of Organizational New Attributes in September

September/New	Coordinator	Logistic service	Donor	Army	Field operators	ETU	Sum
International	5	17	55	2	1	0	80 (25)
National	20	3	4	2	0	0	29
County	0	1	2	0	5	8	16
Community	0	2	3	0	6	0	11
Sum	25	24	62	4	13	8	136

Table 12 Descriptive Information of Organizational New Attributes in October

October/New	Coordinator	Logistic service	Donor	Army	Field operators	ETU	Communication	Sum
International	1	28	72	0	0	0	0	101 (29)
National	22	7	2	2	2	0	0	33
County	2	3	0	0	9	5	1	20
Community	1	12	3	0	6	0	0	24
Sum	26	50	77	2	17	5	1	178

Table 13 Descriptive Information of Organizational New Attributes in November

November/New	Coordinator	Logistic service	Donor	Army	Field operators	ETU	Communication	Sum
International	1	31	131	2	0	0	7	172 (34)
National	14	3	3	1	8	0	3	34
County	6	7	0	2	13	14	0	40
Community	1	7	1	0	12	3	0	24
Sum	22	48	135	5	33	17	10	270

Table 14 Descriptive Information of Organizational New Attributes in December

December/New	Coordinator	Logistic service	Donor	Army	Field operators	ETU	Communication	Sum
International	1	20	53	1	0	0	11	86 (33)
National	14	4	1	2	4	0	7	32
County	4	9	0	0	9	18	1	41
Community	0	5	1	0	3	3	0	12
Sum	19	38	55	3	16	21	19	171

The major fluctuation of the number of participating organizations was caused by a huge change in the number of donors working at the international level. The overall change in distribution of the participating organizations by excluding international donors provides a clearer picture of the network changes. After removing the number of donors on the international level, for the first two months, the international (25 and 29 in Sep and Oct) and national (29 and 33 in Sep and Oct) operational levels were strengthened with the majority of participating organizations. However, for the last two months, the county level operational level (40 and 41 in Nov and Dec) became the most strengthened operational level while keeping the steady number of the participating organizations on the international (34 and 33 in Nov and Dec) and national (34 and 32 in Nov an Dec) levels. In terms of the organizational role, the biggest fluctuation was caused by the participating organizations who served as donors and field operators. In contrast, the number of coordinators, logistics providers, and armies were steady over the period. The participating organizations who support ETUs and communication service steadily increased.

5.3.2 Regression analysis

5.3.2.1 Homophily partnership trend by month

Table 15 summarizes the results of logistics regression analysis, showing the changing trends of homophily effects of each organizational attribute on the predictability of organizational partnerships: Regional location, Operational level, Organizational tier, and Organizational role.

Table 15 Logistic Regression Results

Monthly	**SEP**				**OCT**				**NOV**				**DEC**			
Binary	Est.	EXP(B)	Std.	P-value	Est.	EXP(B)	Std.	P-value	Est.	EXP(B)	Std.	P-value	Est.	EXP(B)	Std.	P-value
(Intercept)	-4.021***	0.018	0.100	0.000	-4.574***	0.010	0.097	0.000	-4.776***	0.008	0.080	0.000	-4.137***	0.016	0.087	0.000
Reg. location	0.604***	1.829	0.118	0.000	0.677***	1.968	0.106	0.000	0.594***	1.811	0.095	0.000	0.613***	1.846	0.109	0.000
Op. level	0.088	N/A	0.124	0.480	0.800***	2.226	0.113	0.000	0.149	N/A	0.102	0.143	0.373***	1.452	0.110	0.000
Org. tier	0.918***	2.504	0.115	0.000	0.711***	2.036	0.104	0.000	0.572***	1.772	0.094	0.000	0.506***	1.659	0.109	0.000
Org. role	0.403**	1.496	0.128	0.002	0.670***	1.954	0.111	0.000	0.982***	2.670	0.102	0.000	0.783***	2.188	0.115	0.000
AIC	2778.5				3483.3				4969.5				3434.1			

***>0.000/ **>0.001/ Reg. location: Reginal location/ Op. level: Operational level/ Org. tier: Organizational tier/ Org. role: Organizational role

In September when unified coordination system was set up, participating organizations had 183% higher chance (β= 0.604 at p=0.000) to create a partnership with ones who came from the same regional location than ones who came from different regional locations. In contrast, the participating organizations did not show significant propensity to work with organizations that worked at the same operational level. In terms of conceptual spaces, the participating organizations showed the strongest propensity to create partnerships with ones categorized in the same organizational tier: 2.5 times higher chance (β= 0.918 at p=0.000) to connect with the same-tier organizations than the chance to work with organizations from other organizational tiers. The participating organizations showed a 150% higher chance to connect with ones who serve the same role than ones who serve different roles in the network (β= 0.403 at p=0.000). In this early period of the Ebola relief logistic network, the creation of partnerships among participating organizations were substantially influenced by organizational existing conditions which were determined before joining into the Ebola relief logistics network. Comparing to the physical proximities, the organizational conceptual proximities as a screening standard of other organizations played a more important role in predicting the partnerships.

In October when the number of affected cases significantly increased, the partnership propensities were changed from September. Even though the participating organizations still had higher tendency to create partnerships with ones who came from the same regional locations—197% higher chance (β= 0.677 at p=0.000), the emphasis on organizational partnerships on the same operational level increased. The organizations showed around 223% higher chance (β= 0.800 at p=0.000) to find partners that worked on the same operational level than on the different operational levels. The organizational tier still played an important predictor to create partnerships. When the organizations were affiliated into the same organizational tier, they had more than 2 times higher chance to be connected than working

with different tier organizations (β= 0.711 at p=0.000). The organizational role in the network also played an important attribute to create partnerships. When organizations served the same role, they had 195% higher chance to be connected than ones who served other roles. In October, the participating organizations started to change their emphasis on new organizational attributes assigned by the relief logistics network, including the operational levels and organizational roles, rather than the existing organizational attributes, including the regional locations and organizational tiers. Compared to the physical proximities, the conceptual proximities proved to be more important factors for the organizations to create partnerships as same as September.

In November when a large number of new participating organizations joined into the network, the organizational regional locations still played an important role in creating partnerships; the organizations had 181% higher chance (β= 0.594 at p=0.000) to be connected when they came from the same regional locations. As was the same as September, the operational level attribute did not serve as a significant predictor to create organizational partnerships. The organizational tier played a reasonable role in predicting partnerships; the organizations affiliated to the same organizational tier showed 177% higher chance (β= 0.572 at p=0.000) to be connected than with ones from different organizational tiers. The organizational role played the strongest role in predicting partnerships. The organizations who served the same role had a 2.67 higher chance (β= 0.982 at p=0.000) to create partnerships than partnerships with ones who served different roles. In this period, the both organizational existing attributes – an organizational regional location and organizational tier— had moderate effects as partnership predictors. The propensities derived by the organizational new attributes showed an opposite pattern. While the organizational role had the strongest factor to create homophily partnerships, the operational role did not have a significant effect. Comparing to

the physical proximities, the conceptual proximities continued to serve as more important factors for the organizations to create partnerships.

In December when the number of participating organizations decreased, the organizational regional locations still played an important role in creating partnerships; the organizations had 185% higher chance (β= 0.613 at p=0.000) to be connected when they came from the same regional locations. The operational level had a relatively smaller power to predict to create partnerships among organizations working on the same level, which 145% higher chance (β= 0.373 at p=0.000) of partnership on the same operational level than on the different operational level. The organizational tier still served as a good predictor –166% higher chance (β= 0.506 at p=0.000)— for partnerships within the same organizational tier. The organizational role kept playing the most important predicting role in creating partnerships—higher than 2 times chance (β= 0.783 at p=0.000)—among the organizations who served the same roles. The existing organizational attributes served a moderate role to predict partnerships in December. In terms of the organizational new attributes, the organizational role was a stronger factor than the operational location to create a partnership. Compared to the physical proximities, the conceptual proximities continued to serve as important factors for the organizations to predict organizational partnerships.

5.3.2.2 Changes of homophily partnership trend over the operational period

Throughout the four-month collaborating period, the organizational homophily propensity based on the regional location played a steady role in creating partnerships, which rejects Assumption 1. Even though a regional location indicates physical proximity, this information implies a value sharing in culture and norms. And those common values could be very important factors to build communal trust that reduces the perceptive transaction costs in

uncertain situations. The steady effect of the regional location signifies the fundamental mechanism of organizational behaviors.

The homophily trend of the same operational levels in the relief logistics network are not steady, which rejects the Assumption 2. This trend should be understood based on the unique situational context of each operational month. Even though major coordinating organizations set up an unified coordinating system at the national level in September, they closely worked with headquarter offices of those coordinating organizations including WHO and CDC to develop operational plans and protocols in detail. The October network showed a strong homophily propensity at the same operational levels. The strong homophily propensity at the same operational level may indicate a parallel operational system. Even though the participating organizations had a strong horizontal coordination, those organizations had a lack of vertical coordination and collaboration across different operational levels. One interviewee mentioned that a huge operational gap existed between national and county levels. Because their management and reporting systems were incompatible and sometimes conflicting between national and county levels, the coordination between different operational levels was challenging.

"The logistics in between Monrovia and County were somehow completely different. You are getting two different messages. We would do something with the county's permission, I will then go to a meeting and get totally blasted by the Ministry of Health from the Monrovia side (Interviewee 29)."

To react to a rapid increase of affected cases in the late October, lots of organizations joined in the relief logistics network in November. As the number of international donors rapidly increased shown in Table 13, lots of relief items should be transferred from international to national levels. This situation required lots of transmission of information and

resources between international and national levels. To manage the unpredictable spread of affected cases, the coordinating organizations at the national operating level sent several health teams to each county to effectively investigate local situations (Centers for Disease Control and Prevention, 2015). At the same time, the logistic service organizations started to coordinate with county governments to plan and set up county-level logistic hubs (WFP, 2014). No significant homophily effect of the same operational level in November reflects this vertical coordination and collaboration situation in November. The number of affected cases steadily decreased until December. As the situation was stabilized, the coordination routines for both horizontal and vertical collaboration is assumed to be settled down, signifying the moderate homophily effect of the same operational level.

The organizational homophily propensity based on the same organizational tiers substantially decreased over time even though its effect was still significant in December. The assumption 3 is accepted. Even though the similarity of institutional structure could avoid unnecessary procedure conflicts in an ordinary situation, this unprecedented situation in a new environment required a new coordination and operational process to meet particular contextual needs. Also, this phenomenon shows a process of how an organizational bias or a conceptual barrier toward certain organizational tiers became dilute through their communication and working experiences over time. Several interviewees joined as major international coordinating organizations in the network empathized that their biases toward the Liberian national government and the local NGOs in a community were removed when they experienced a successful collective action.

"You might think this entity (a local NGO) is so small, but then when you hear the interventions they're doing in that small locality, it's amazing because then that stops the spread of the virus to that location. If they were not there then it's like they're their preventive (Interviewee 10)."

The homophily propensity based on the same organizational role steadily increased, reaching to the peak in November, and maintained a high homophily level in December. The assumption 4 is accepted. This result reflects the current international collaboration approach. The UN cluster collaboration framework divides participating organizations into several working clusters. Each working cluster has an internal coordination to manage and decide its working task in detail. The leading organizations from each cluster have an external coordination to exchange information and support one another across different working clusters (WHO, 2012). If coordinators from different clusters have a close coordination, this coordination pattern also reflects a homophily propensity within the same organizational role statistically. Based on these characteristics of coordination, the increasing homophily propensity based on the same organizational role could be interpreted in two different ways. The first possible interpretation is that the coordination both within the same role and across different roles was strengthened over operational period. The other possible interpretation is that the coordination could be strengthened only within the same role with a lack of coordination among different clusters. To understand this statistical implication precisely, additional information about the coordination mechanism and its changes during the Ebola relief logistics network is necessary.

5.4 Conclusion and Discussion

This chapter shows the homophily behavioral trend derived by organizational existing and new attributes on developing partnerships in uncertain situations. To reduce their transaction costs in collaboration, participating organizations use organizational attributes as a strategy to screen favorable partner organizations out of lots of unfamiliar organizations.

However, this individual strategic partnership cannot guarantee the improvement of the entire system performance. Too much emphasis on homophily actions based on existing and new organizational attributes can cause the partitions undermining cross- role and cross-operational coordination. Those partitions limit the participating organizations to grasp the whole operational progress and system changes. Rather, the participating organizations are limited geographically and conceptually in what they see and know. Those narrow views, in turn, decrease their capacities to prepare for unexpected changes. Consequently, the organizational narrow views in creating partnerships may lead an unfavorable or vulnerable collaboration structure as a whole. Collaboration across diverse types of organizations creates synergies, providing responsiveness to external environmental changes. The result of a whole collaboration is more than the sum of parts (Page, 2010). In this reason, it is critical to see how the trend of individual organizational behaviors in creating partnerships contributes to developing certain features of the network.

In contrast to the assumptions, the organizational behavioral trends to create homophily partnerships were not consistent. This inconsistent behavioral tendency signifies that organizational behavioral changes do not occur naturally. Rather, their standards to choose certain behavioral kept changed through a certain mechanism. The statistical interpretation requires detail information to explain what mechanism caused organizations to change their behavioral preferences in creating partnerships.

6.0 The Evolving Trend of the Collective Action Structure in the Relief Logistics Network

This chapter highlights a structural perspective of the network evolution by analyzing the network features in terms of distances and resilience of communication and resource flows among participating organizations, which ultimately aims to increase network performance. Under the very complex institutional contexts with an unpredictable epidemic pattern (See more details in Chapter 4), the participating organizations in the relief logistics network strategically found their partners by using organizational attributes to improve collaborative performance (Chapter 5). These individual organizational experiences are finally built up to form larger-scale aspects of a social network. The network is well beyond the control of any one organization. These individual organizational adaptations lead the evolution of the entire coordination structure of a relief logistics network. Those individual organizational actions might not contribute to increasing the performance of the entire network due to limited information and perceptions toward surrounding environments for a short-term. Through a self-organizing and co-evolving process for a long period, those participating organizations will look for ways to create an efficient and resilient collaborative structure consisting of horizontal and vertical flows of a relief logistics network. The whole network evolves until the entire system reaches to an optimal level of performance to meet a particular need in an environmental context. This chapter introduces: 1) the evolving mechanisms of network evolution; 2) the measurements of the evolving mechanism; 3) analysis of the evolving trends of the relief logistics network during the Ebola crisis; and 4) a summary of the analysis and conclusion.

6.1 Network Evolving Trend

Institutional collective action illustrated in chapter 5 indicates that individual organizations try to minimize risks in creating partnerships to ensure a collaborative performance, using individual organizational attributes. In the long-run, the participating organizations also seek to achieve a better performance through a relational structure derived from multiple relationships in the network. The structure of the relational network is important to direct and indirect connections. The spillover effects through direct and indirect connections impact the performance of the interdependent participating organizations (Bingham, O'Leary, & Carlson, 2014; Kapucu, 2006; Klijn & Koppenjan, 2000; Lee, Feiock, & Lee, 2012). The performance in a relief logistics network is also shaped by environmental and contextual factors interacting with organizational factors. Because of individual and interacting effects of diverse factors in a network, a relief logistics network is featured with dynamic structures that change and evolve over time (Abbasi & Kapucu, 2012; Gulati & Gargiulo, 1999).

The performance of the entire relief logistics network is determined by both horizontal and vertical collaborations. Horizontal collaboration is often categorized as interlocal and intersectoral collaboration where diverse types of organization on the same operational level create a collective action (Agranoff & McGuire, 2003; Lazzarini, Chaddad, & Cook, 2001). Collaboration among the same type of organizations increases resources and expertise. The current UN cluster framework provides a basic collaboration structure by grouping organizations that have the same types of resources and skill sets, aiming to increase a task-focused capacity. Collaboration across different types of organizations creates synergy to find and support the third type of tasks by matching complementary resources and skills (Page, 2010). The collaboration across different types of organizations adds uncertainty as

organizations seek the right partners with compatible resources to fill the gaps in knowledge and resources.

Vertical collaboration occurs when organizations located at different operational levels work together. A relief logistics network is structured in to international, national, county and community levels. Each operational level supports a relief logistics network with different types of tasks. The upper levels, such as international and national levels, are best positioned to prepare a national plan, collect relevant resources, and manage those resources, whereas the lower levels, such as county and community levels, are positioned to implement the national plans by distributing assigned resources to relevant recipients. The performance of each operational level is interdependent (Barratt, 2004; Xu & Beamon, 2006) because the tasks in each operational level correspond to one another as they flow across the operational levels to achieve the ultimate goal (Giannoccaro & Pontrandolfo, 2003). For example, if coordinating organizations at international and national levels do not fully understand the on-going situations in each community, such as the number of affected cases and community capacities, their national plan and resource allocations that fail to meet the right needs in each community.

A real situation in the field also requires collaboration among different task organizations across different operational levels. Donors at the international level need to work with national logistic service organizations to store their items at the national hubs, while collaborating with local recipient organizations that receive the resources and operate field operations. To help participating organizations to find the right partners across tasks and operational levels to collaborate, the information and resources should not only flow fast enough but also reach extensively. The participating organizations in a relief logistics network should have quick access to information and resources in a wider range of the network. Meanwhile, a relief logistic network should have a resilient structure, returning to a normal function from an uncertain disruption. In the Liberian context, international logistics service

organizations working as a logistics cluster were unfamiliar with local transportation conditions and efficient routes. When their vehicles were not fit for the very narrow and unpaved local roads to remote counties and communities, those international logistics service organizations needed local logistics service organizations that could replace their role to deliver resources to the final destination with an appropriate transportation system. Otherwise, the operation of the entire relief logistics network is disturbed due to the interruption in the flow of resources.

Collaboration across different types of organizations and different operational levels in a relief logistics network leads to challenges in practice. The current UN cluster coordination framework provides the common ground for participating organizations based on the same or similar skillsets. Within-cluster coordination has been the most successful to date. Yet, too much emphasis on within-cluster coordination of the current framework makes it more difficult to achieve between-cluster and supply chain or vertical coordination (Jahre & Jensen, 2010). This framework missed a critical point of how to synchronize existing relief logistics network in the field from international throughout community operational levels. By analyzing empirical evolutionary paths of a relief logistics network in response to the 2014 Ebola crisis, this chapter explores significant features of the network to enhance efficiency and resilience, which support the operation of a relief logistics network as a whole.

6.1.1 Short-term evolution trend of a network: Segmented clusters

Social networks evolve to develop an efficient structure of a network by shortening distances among participating organizations, which enhances the circulations of information and resources. When the number of participating organizations increases in the network, it is more complicated to develop an efficient network structure. A network evolves to increase efficient interactions among many participating actors by clustering smaller groups. The nodes

that have more interactions are locally clustered with a shorter distance in average, which is called small world (Milgram, 1967). This clustering feature is universally found in network studies examining diverse types of people and organizations (Baum, Shipilov, & Rowley, 2003; Brian Uzzi & Jarrett Spiro, 2005; Davis, Yoo, & Baker, 2003; Kogut & Walker, 2001; Newman, 2001; Watts, 1999). Granovetter (1973) suggested that people or organizations have high chances to create ties with "the friends of their friends" (p.1362) (or the business associates of their business associates), because people who spend time with a common third have a high chance to incidentally encounter each other, even if they do not intend to do so.

This closed relationship is created through referrals by sharing information about potential connections, and this connection created through referrals decreases the uncertainty and risk of a new connection (Burt & Knez, 1995). Research on social capital has noted that embeddedness among third parties also promotes collectively oriented norms which help to minimize opportunistic behavior risks (Granovetter, 1985; Uzzi, 1997, p.48) and conflicts (Krackhardt & Handcock, 2008; Portes & Sensenbrenner, 1993; Simmel & Hughes, 1949), which is critical issue in creating a collective action in uncertain situations. Actors who communicate with others frequently develop mutual trust, and those actors who have more frequent communications are more likely to share knowledge than those who communicate infrequently. Stronger attachment among actors in a cluster decreases risks being associated with incomplete information, while strengthening sanctions to increase mutual trust (Hur & Park, 2016). This process promotes the transfer of more complex knowledge among actors within a cluster (Hansen, 1999; Szulanski, 1996; Uzzi, 1997) than with actors outside of the cluster, because they are more likely be embedded in a dense web of trustworthy relationships (Cozzolino, 2012; Maskell & Malmberg, 1999).

This clustering tendency is also commonly found in inter-organizational collaboration as organizations look for cues about potential partners from their current partners (Gulati, 1998;

Gulati & Gargiulo, 1999). If two organizations have a successful collaboration, it is likely that a partner organization that collaborates with one of these two organizations will also collaborate with the other. Indeed, this way of finding a partner decreases risk to initiate a new partnership compared to a new partnership with unfamiliar organizations (Gulati, 1995). Cognitive consistency theory supports a structural tendency toward closed transitive relationship in the interorganizational network among development organizations (Holland & Leinhardt, 1976). Clustering tendency plays a role in increasing efficiency of information and resource flows within a small number of people in a short-term.

However, too much clustering tendency in a network decreases resilience of the network by segmenting a network with separate clusters in the long term. Closely connected people or organizations usually share the similar evaluations or attitudes toward other people, organizations and the world. This similar ideas and information among actors within a cluster are very redundant (Holland & Leinhardt, 1976). This cluster eventually will be deprived of information from distant parts of the social system and be confined to the local narrow view. The clustering tendency well reflects an organizational homophilic tendency to create a partnership. When actors of a network have very strong homophilic tendency unto a certain institutional value to create partnerships, each cluster would be very unique and less likely to be connected with different clusters. This phenomenon causes lots of structural holes between disconnected clusters, forming a segmented network. A structural hole, a lack of ties among clusters, limits the accessibilities to diverse information (Hur & Park, 2016). The segmented network with lots of separate clusters is very vulnerable to uncertain disturbances that cause an ordinary system to break down.

6.1.2 Long-term evolution trend of a network: Overlapping clusters connected through weak ties

The resilience of a relief logistics network increases when the network is steadily connected as a whole through many connections across different clusters even with unexpected disturbance in a network. A relief logistics network is broken down when the network no longer has a connection to send resources and information from one to another due to disruptions of certain types of organizations and their connections. Major challenges in the current cluster coordination system come from how to connect all structural holes not only across different tasks and operational levels but also between existing and emerging coordination systems (Adinolfi et al., 2005; Stoddard et al., 2007). Interestingly, denser or merely more complex networks do not necessarily have higher resilience. This implies that the redundancy of many connections may not always lead to higher resilience (Kim, Chen, & Linderman, 2015). Rather, the resilience of the network can increase through multiple organizations bridging different clusters across tasks and operational levels so that upstream and downstream information keeps flowing throughout the network.

These bridging organizations are called 'weak ties'(Granovetter, 1973) across different clusters, whereas partnering organizations closely connected within the same cluster are called strong ties. Weak ties, typically leads to alienation (Wirth, 1938), but are indispensable to learning opportunities and to their integration into communities. By bringing novel information and resources into a strongly-tied cluster (Robinson, 2012), weak ties lead to overall fragmentation of localized cohesion. A structural hole between two groups does not mean that people in groups are unaware of one another. It only means that the people are focused on their own activities and do not attend to the activities of people in other groups. These holes are like buffers, like insulators in an electric circuit. People on either side of the

structural hole circulate different flows of information, or, referring back to Bernstein (1971), different codes of communication. Structural holes are the empty space in social structure (Burt, 2004). Through a bridge or through a weak tie, and perhaps only through this bridge, a member in one group may learn and gain information about the other group. If that information is useful, then whoever has access to and use the bridge and their affiliating cluster will gain an advantage. With more weak ties in a network, new ideas will spread faster, and the benefits of information can spill over efficiently throughout the network.

The overwhelming predominance of weak ties, even if structured, produces and shape a structure where each cluster overlaps extensively with many others as many weak ties serve bridging functions. Clustering can occur even between individuals who are separated by more than a single intermediary. In a network, the distance from one actor, i, to another, j, is denoted d_{ij} and represents the length of the shortest path between i and j. Individuals who are not directly connected themselves, but who are connected to a common third actor, are separated by a distance of 2. People separated by two acquaintances have a distance of 3. In this sense, new ties are more likely to be formed between people who are not only close in a network, but also close through numerous independent intermediaries. Therefore, when clusters share multiple weak ties, clusters overlap and, even merged into a bigger cluster, within a network. This overlapping feature of multiple clusters in a network enables not only to circulate useful information fast (Brian Uzzi & Jarrett Spiro, 2005; Moody, 2004) but also to increase the resilience of the network with a lower chance of disconnection of the network under a sudden attack, which ultimately increase the network performance.

A social network evolves to shorten a distance over time, continuously becoming more clustered. However, this clustering tendency changes from small-close segmented clusters to wider-open overlapping clusters, which increases both efficiency and resilience of the network.

This research assumes that the 2014 relief logistics network would evolve from small-close segmented clusters to wider-open overlapping clusters over a response operational period.

Assumption: The 2014 relief logistics network would evolve from a segmented network feature with small-close clusters to a connected feature with wider-open overlapping clusters over a response operational period.

6.2 Measurements of the Network Evolution Trend

This section introduces two different perspectives to measure the network evolution trends. The first purpose of a network analysis is to understand the network components. The relief logistics network in response to the 2014 Ebola crisis in Liberia was composed of different types of organizational functions at different operational levels. The distribution changes of organizational roles and of operational levels in the relief logistics network from September to December demonstrated how the emphasis on certain organizational functions and operational levels had changed in the network over the operational period. The second purpose of the network analysis is to understand how the network structure had evolved. The network structure plays an important role in determining an operational performance by quickening or slowing down information and resource flows even with external internal disturbances. To be specific, the structural evolution demonstrates how the relief logistics network evolved to establish an efficient and resilient structure.

6.2.1 Network components

6.2.1.1 Major organizational roles

Participating organizations in the relief logistics coordination network served five types of roles and functions: coordinators, logistics service providers, donors, telecommunication supporter, field operators (Kovács & Spens, 2008; Schiffling, 2013), militaries, and other services as needed. The relief operations coordinator plans, activates, and supports specific relief activities. For example, as of the relief coordinators, the host government, activates the humanitarian logistics stream after a disaster strikes since the host country has the legal authority and protocols in place to support operations and mobilize resources. Other actors cannot replace the function and resources of the host government. By activating an official call to drive the intensive international partnership , international organizations support and coordinate with the host government and other major relief coordinators as appropriate (Kovács & Spens, 2009). In response to the Ebola crisis, the UN Mission for Ebola Emergency Response (UNMEER) and the World Health Organization (WHO) were official leading coordinating organizations (WHO, 2014).

Logistics service organizations transmit information and resources across different operational levels from donating organizations to assigned recipient organizations that implement their response operations. Without their logistics services, the operational plans cannot be realized into practices in the field. The World Food Program (WFP) is a major international organization that provides food and non-food but daily necessities to countries in complex situations and challenges. To deliver such life-saving resources, the WFP has developed specialized logistics systems which includes: the transport and storage of general cargo and non-food items, the transportation of aid workers, coordination, and the provision of training for logistics staff. The WFP has played a leading role in a relief logistics network to

serve logistics functions necessary in international, national and county levels (Quinn, 2010). International private or nonprofit logistics organizations also voluntarily participate in delivering and storing relief items from international to national levels. For the last mile logistics, local NGOs and volunteers play an important role as last-mile logistics service providers in distributing relief items to each household.

Dispatched militaries play a wide range of functions in a relief logistics network as a specialized and well-prepared organization in response to a disaster. Militaries provide a professional logistics service supported by well-trained armed forces and physical capital resources such as: specialized equipment, diverse transportation means, and communication and information systems. Their specialized skills and resources play a critical role in efficiently building temporary facilities or recovering destroyed infrastructure during a disaster situation. Depending on the situational needs and assigned tasks, militaries also provide security services to other partner organizations or citizens. They have a clear hierarchical command-and-control structure to efficiently and effectively coordinate an emergency situation (Kovács & Tatham, 2009).

A major purpose of the relief logistics system is to deliver resources. Without donors, relief logistics cannot be activated. Many foreign governments donate relief funds, items, and human resources via international public or nonprofit organizations or directly to the recipient governments. International or regional collaborative organizations, such as European Union and African Union, collect relief funds from member states. Foreign governments and regional organizations can draw a relatively significant amount of resources from their national and regional union budgets, respectively. The private sector also participates in providing resources to support relief operations by either collecting donations from their customers and partners or by offering their expertise or products. A few international nonprofit organizations send resources donated by the private sector organizations and individuals; these nonprofit

organizations are an important channel for the public to participate in supporting relief operations.

Telecommunication organizations play a critical role in supporting the communication flow for coordination among participating organizations across different operational levels. The rapid passing of time dynamically changes the disaster situation, which may require different relief items and kinds of assistance. Since participating organizations from the relief logistics network are not familiar with local conditions, the relief logistics and operations need supporting communication systems that respond in a timely manner (Large, 2005; Nketia, 2008). By providing relevant, accurate, and timely information about the field conditions to the decision-makers, the relief logistics network can improve the decision-makers' performance (Simatupang, Wright, & Sridharan, 2002). Organizations that specialize in logistics, such as the WFP and militaries, have their own communication system to track their activities. Private information technology (IT) organizations, such as mobile telecommunication and software application companies, also provide infrastructure and services to support logistics activities.

The field operating organizations that usually work on a county or community level represents the fifth function of the logistics network and serves as the destination of the relief items. The activities on the field range widely from education campaigns and resource distributions to each household to health care or family care services. Each community are supported with different types of services based on the extent of damages and located NGOs' expertise and resources. Nonprofit involvement in health care services has been imperative during public health emergency operations in developing countries to fill the gap of public health capacity (Beyrer et al., 2006; Liebowitz, 2002). Many international and local nonprofits are usually on the front line by setting up medical facilities, supporting local public health systems, educating the locals, and providing shelters and necessities to victims (Liebowitz,

2002). When the local nonprofits participate in the field operation such as awareness campaigns and case investigators supported by the relief items from the logistics network, their local knowledge greatly contributes to maximizing the speed of the logistics operation (Kovács and Tatham, 2009). The Ebola crisis required specialized skills to deal with patients and a new type of health facilities, called Ebola treatment units (ETUs). ETUs took a leading role in quarantining and caring affected cases at a county level to limit a further spread. Only qualified organizations could join ETU operations.

6.2.1.2 Operational levels

The relief logistics network is coupled networks consisting of international, national, county and community operational levels. The majority of donors such as foreign governments, international organizations, and international NGOs participate in a response operation through donations without entering into the field. The international operating level serves an important role in drawing lots of resources by creating collective actions such as holding an international conference or forum among foreign governments. A national emergency operation center (EOC) takes place on the national level for the first time. Host governments and international governance organizations, such as UN agencies, are coordinated and work together to develop a national response plan and allocate resources based on updated situations from communities. Diverse participating organizations and resources also join the EOC in order to support the national implementation plan. The leading organizations in EOC require high capacity to engage and coordinate different participating organizations to serve particular tasks and to gather relevant information in a timely manner from the participating organizations across operational levels. Without effective coordination, resources and operations could overlap one another, which waste time and resources. Without timely information, the national plan fails to reflect the most urgent needs in the current situation.

A county level, also called a provincial level, plays a role as a strategic field by bridging between national and community levels. The national operational plan provides general guidelines of the policy goal, objectives and directions. Meanwhile, the coordinators in the county level should develop and operate strategic actions reflecting the particular context of its county and affiliated communities. The county serving as a meso-level provides basic structural building blocks of political, economic and administrative systems in the society (Fligstein and McAdam, 2010), which creates different results even from the same problem. This fact indicates that policy adaptation should be made on the county level. A community level is the operational arena where field operators such as local NGOs and volunteer groups directly support individual victims and households. Most participating organizations in the community level are sponsored or hired by certain donors to serve certain types of operations and recipient groups. A community is the smallest collective unit in a society where social culture and norm substantially influence individuals' behaviors. The real success of policy implementation aiming people's behavioral changes occurs at the community level.

6.2.2 Network structure

This section analyzes macro and micro features of a network structure that increase efficiency and resilience of a relief logistics network. A macro perspective of an efficient and resilient relief logistics network is characterized with short paths covering a wider range of network among participating organizations. 1) A diameter indicates the entire size of the network measuring a length between farthest actors. When additional organizations join the network, the network is likely to expand (Hanneman & Riddle, 2005). The second attribute of macro perspective of a network is to see how widely participating organizations are reachable to each other through shorter paths even if the size of the network is very big. An actor is "reachable" by another if there is a set of connections by which we can trace from the source

to the target actor regardless of how many organizations they need to pass through to be connected. Some actors cannot reach one another because of structural holes between disconnected small clusters. A more ideal structure is when participating organizations are reachable through a shortest path rather than a longer path. 2) The reachability and 3) the average length of shortest paths, called geodesic paths, within a reachable network serve important indicators to present overall efficiency of a relief logistics network. The fourth attribute of an efficient network structure is to see how individual participating organizations are accessible to shorter paths. When organizations are connected by many shorter paths across the entire network, such as a partnership with many weak ties, they can obtain the shortest path to reach information and resources. A node A's betweenness centrality indicates the ratio of all shortest paths between nodes that include node A (Freeman, 1977). Consequently, an average betweenness centrality represents how the network is structured to provide efficient accessibility of all participating organizations to the shortest paths in average.

To identify specific structures and strategies that increase both the efficiency and resilience of a network, I also include measurements which demonstrate how multiple smaller clusters overlapped one another via weak ties. Even with a large network, participating organizations can shorten the lengths by creating a smaller cluster among those who closely and frequently work together. The transitivity, also known as clustering coefficient, indicates relational trend among nodes to develop triadic closure. The transitivity is measured with "the average probability of two neighboring nodes that are connected to a given local node also being connected to each other" (Mari, Lee, Memon, & Park, 2015, p. 106). By connecting with the common node, a triadic closure relationship makes the relationship more efficient within that group. The value of transitivity 0.24 indicates that, on average, the chance that two people that share a common partner is almost one-fourth, which is rather high probability. A triad is a

meaningful sub-set of relief logistics network to increase information and resource circulations (Childerhouse, 2013).

In addition to efficient circulations of information and resources within a smaller cluster, the ultimate goal of the network evolution is to strengthen resilience and efficiency as whole by filling in the structural holes. Ideally, a resilient network develops a network consisting of connected or/and overlapped clusters. The proportion of weak ties in a network signifies the possibility/future tendency to create connected networks among segmented clusters in a network. High proportions of weak ties in a network contribute to accelerating flows of diverse information throughout the network by connecting among different clusters through shorten distances across different clusters.

Communities indicate how the network can be partitioned into distinctive groups. In contrast to a triadic closure form of transitivity, communities represent an open and bigger clustering structure involving multiple triadic closures connected through weak ties. To detect the number of communities, the network analysis program conducts an iterative analysis process. The first process is to calculate betweenness of every node, and then cut the edge with highest betweenness. Afterwards, the program recalculates the betweenness of every node. This step is repeated until separate communities are formed based on certain density of connections among nearby organizations (Girvan & Newman, 2002). This information provides evolving pictures of how the network was shaped through overlaps among multiple communities through weak ties within a different size of network.

Even in a bigger network with a great number of participating organizations, the participating organizations can reduce their distances through direct or indirect connections through partner organizations. The macro features of network evolution pattern are analyzed with diameter, reachability, average geodesic distance and average betweenness. The micro features of network evolution pattern are analyzed with transitivity, proportions of weak ties,

and communities. Through those features, the following section illustrates how the network has developed efficiency and resilient features in a relief logistics network over operational period.

6.3 Evolving Trends of the Ebola Relief Logistics Network

This section analyzes and compares a series of changes of network structural components and features corresponding to changing situations during the response operation from September to December in 2014.

6.3.1 Network components

6.3.1.1 Distribution changes of the organizational roles

Figure 10 summarizes the proportions of organizational roles in the network through four months.

(number): the number of organizations

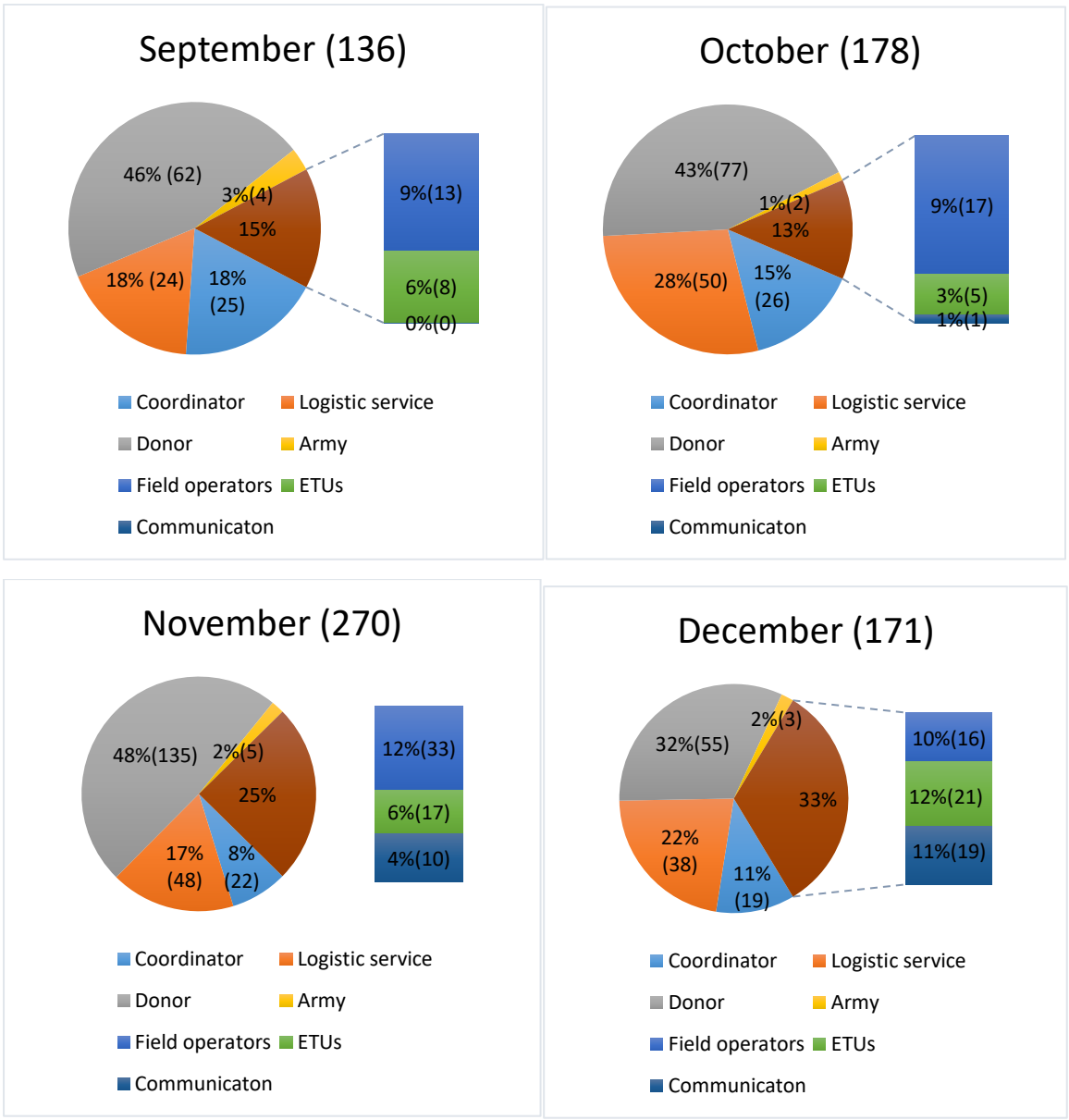


Figure 10 Distributions of Organizational Roles in the Network

The number of participating organizations changed in the relief logistics network from September to December. This fluctuation led the changes of distributions of each organizational role over time. These changes indicate which role was emphasized or strengthened over other organizational roles. September was the first month when an international-national unified emergency operating center was set up in Liberia (Nyenswah et al., 2016) and an international coordination system United Nations Mission for Ebola

Emergency Response (UNMEER) came into Liberia (WHO, 2014) to create a joint effort among all participating organizations. This unified coordination system played a significant role in collecting and exchanging all relevant information and resources, developing response strategies, and dividing participating organizations into certain roles to serve a relief logistics network. During September when the number of affected cases rapidly increased, the network set up with high proportions of donor (46%), coordination (18%), and logistics service organizations (18%). Under a short of resources in Liberia, organizations' active participation in donation was very necessary. Logistics service organizations planned to deliver and manage those donated items from abroad to Liberia, because after the official declaration of the international response in August, Liberia received a surge of donated relief items. The organizational roles of military (3%), field operation (9%), specialized health facilities (6%) (Ebola treatment units, ETUs) and communication (0%) stayed at a marginal level. This indicates that the relief logistics network was not capable enough to provide appropriate cares for affected cases.

In October when the affected cases sharply increased, the logistics service function was more strengthened as the participation of logistics service organizations increased from 18% to 28%. Donating (43%) and coordinating (15%) organizations stayed a major function in the network. These three major functions in the network indicate that major coordination focused on procurements and distributions of resources among donor, coordination and relief logistics service organizations with extra logistics supports. In contrast, the capacity to support affected cases stayed at the marginal level with very limited numbers of field operating organizations (9%) and ETUs (3%). Considering that the number of affected cases increased throughout communities, these minimal proportions of field operating organizations and ETUs reflect that practical assistances to households and individuals had not been reached to communities yet. A communication function (1%) was initiated by just one organization. With a limited internet

access in rural and remote areas in Liberia, the relief logistics network had a lack of effective communication channels to circulate information to coordinate operations across participating organizations if those organizations did not have their own internet infrastructure. The contribution of military organizations was considered as a marginal level (1%) according to the mere proportions of participating organizations.

Since the end of October, the number of affected cases had rapidly decreased within a short period and steadily throughout November. In contrast to the decreasing trend of the affected cases, the proportion donating organizations far increased to 48%. This aggressive participation of donating organizations was caused by international calls made to draw more resources in response to the rapid increase of affected cases at the end of October. Since the number of organizations which served as coordination (8%) and logistics service (17%) roles maintained the steady level, their proportions in the network relatively decreased, respectively. The proportions of organizations that served field operations (12%), ETUs (6%), and communication (4%) increased slightly. The supports from the relief logistics network in November just started to arrive for patient care, practical care for individual residents, and communication services.

In December the number of affected cases steadily decreased. This stable environment reaching to an optimal performance made the operation of the relief logistics network steady and regular. Reacting to this stable situation, the majority of donors left the relief logistics network (32%). Their leaving contributed to far decreasing the size of the network in terms of the total number of participating organizations. In contrast, the number of participating organizations that served coordination (11%) and logistics service (22%) kept the steady level, which relatively increased the proportions in the network. Not only proportions (10%) but also the mere number (16) of field operating organizations decreased, whereas the proportions of

ETUs and communication service organizations far increased: from 6% to 12% and from 4% to 11%, respectively.

These changes of distributional proportions of organizational roles demonstrate provide a general picture of how participating organizations in the relief logistics network had adapted, reacting to changing situations. The organizational function which requires high expertise, skills and resources such as coordination and logistics service steadily support the relief logistics network regardless of situational changes. In contrast, the organizations that supports donating resources and field activities are very fluid sensitively reacting to changing environments: free entrances and exits of the network. Organizational functions which require physical infrastructure in the field, such as health facilities and communication services, takes a longer period of time to increase their operating capacity. Because of this delayed feature, those functions were not very responsive to meet urgent needs the situation requires.

6.3.1.2 Distribution changes of the operational level

The distributional changes of organizational roles show that donor organizations are the most fluid group. The donor organizations' frequent movements confuse the real significance of operational levels where other major organizations that steadily served coordination and logistics service functions focused on. To be specific, because lots of donor organizations increasingly participated at an international level, their participations could lead a wrong conclusion that the international level was the most important operational level. To minimize such confusion, Figure 11 summarizes proportional changes of operational levels based on other organizational roles to support the network steadily, excluding donor organizations.

(number): the number of organizations without donating organizations

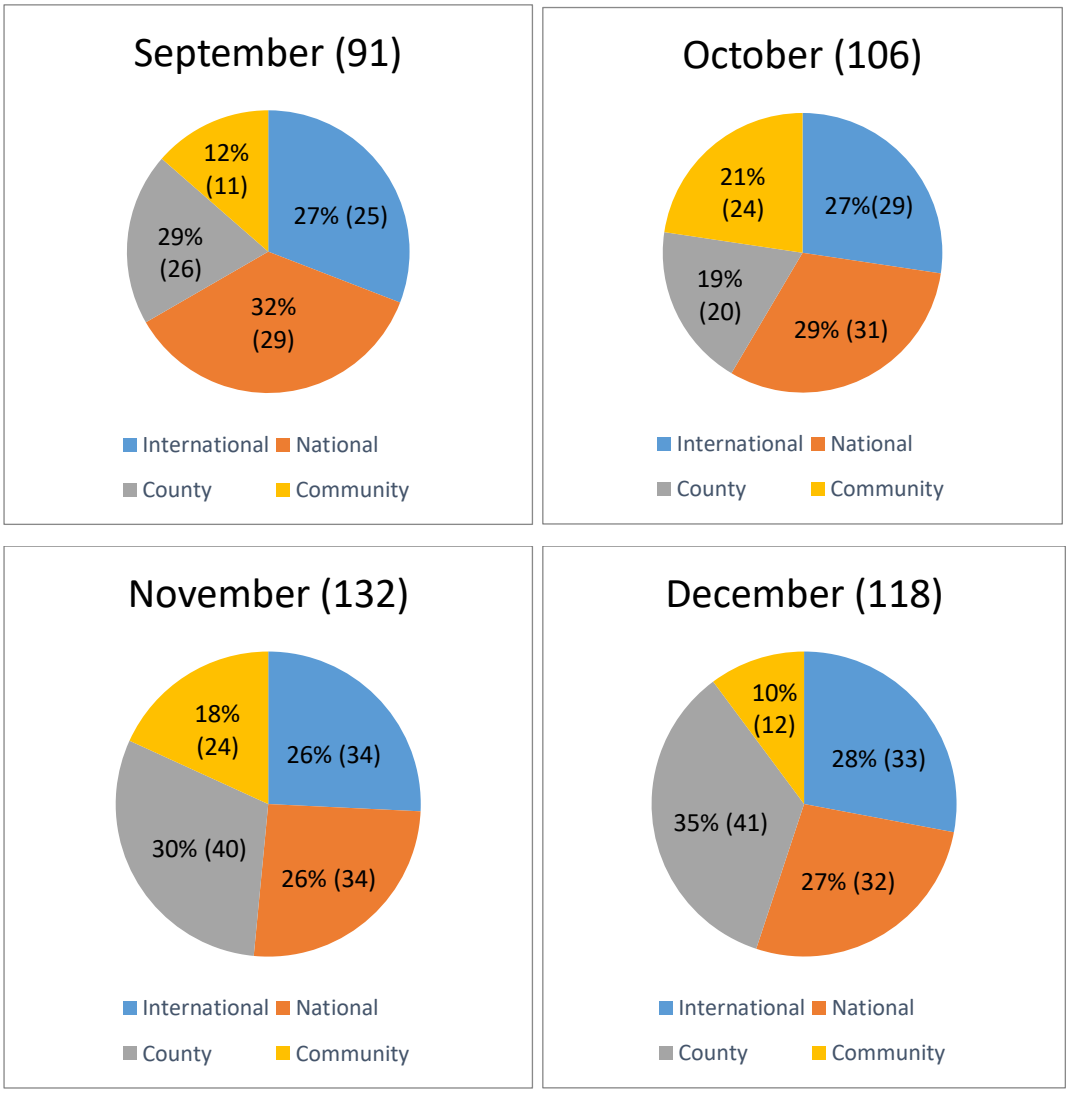


Figure 11 Distributions of Operational Level in the Network

In September when the unified EOC system set up at the national level, all participating organizations needed to join in the EOC on the national level. The September chart reflects this context, showing the national operational level (32%) took the biggest proportion of the participating organizations in the network. Participating organizations were quite equally distributed across international (27%), national (32%) and county (29%) levels. The community level (12%) had less organizational supports in the relief logistics network. In October, majority of participating organizations still concentrated on international (27%) and national (31%) levels. Interestingly, the community operation level (21%) was strengthened

with a big increasing number of participating organizations while the county level (19%) was relatively weakened with the decreasing number of participating organizations compared to September. These proportional changes reflect a situation when many international organizations directly worked with local organizations in communities, and governmental staff in counties left their jobs and tried to work with international organizations (Interviewee, 21).

The emphasis on the operating levels substantially changed in the network in November. The biggest change was found at the county level. The county level started to play a stronger role at the operational level, increasing from 19% to 30% in the relief logistics network. This increase at the county level reflects the fact that in the end of October, the national EOC started to send staff to the county level to strengthen the county-level health teams in affected counties. This purposeful allocation of manpower into the county level aimed to increase the responsiveness to remote hot spots (Nyenswah et al., 2016). In contrast, the national and community levels received less emphasis, decreasing from 29% to 26% and from 21% to 18%, respectively. The organizations' proportion at the international level (26%) maintained the similar level of participation as previous months. In December when system operation was very stable with an optimal performance, the county level became even stronger with higher proportions of participating organizations (35%). The international (28%) and national (27%) operating levels remained steady. The community level seemed to be weaker with lower proportions of participating organizations (10%).

Overall, the significance of the international level remained steady between 27-28% over the entire operational period. The significance of the national level steadily decreased over time. In contrast, the significance of the county level started to be highlighted in November and more strengthened in December. As a result, the county level played a role as the most important operational level in the last two months. The significance of the community level peaked in October, and steadily decreased November and December.

6.3.2 Network structural level

This section focuses on the evolving trend of the network structural changes contributing to efficiency, resilience and coherency. Table 16 summarizes changing trends of these three aspects in the network over four- month period.

Table 16 Evolution Trend of the Network Structure

		September	October	November	December
No. of Orgs.		136	178	270	171
Macro features	**Diameter**	7	9	9	9
	Reachability	0.31	0.20	0.17	0.28
	Ave. Geodesic	3.25	3.57	4.31	3.68
	Ave. Betweenness	91.07	88.55	150.98	127.22
Micro features	**Transitivity**	0.17	0.21	0.10	0.14
	4-steps clustering track	24 groups (Mode: 0.56)	31 groups (Mode:0.64)	40 groups (Mode: 0.62)	31 groups (Mode: 0.53)
	Proportion of weak ties	0.68	0.72	0.81	0.74
	Communities	17 groups (Mode:0.59)	22 groups (Mode: 0.64)	24 groups (Mode: 0.67)	17 groups (Mode: 0.57)

6.3.2.1 Evolution trend in macro features of the network

From September to October, the diameter increased from 7 to 9 when the number of participating organizations increased in the network. Even though the number of participating organizations increased in October and November and decreased in December, the diameter kept the same length. This general picture implies that the increasing number of participating organizations was not randomly located in the network. Rather, those organizations tried to avoid inefficiency caused by an increasing size of the network. In general, a relief logistics network becomes less reachable when the number of participating organizations increases. The reachability of the September network where the least number of organizations participated was 0.31. In October, the reachability of the network far dropped to 0.20, continuing to

decrease to 0.17 in November when the biggest number of organizations participated in the network. When lots of organizations left the network in December, the network became more reachable (0.28). However, the decreasing gap of reachability caused by the increasing number of organizations became less and less over time. The reachability decreased by 0.11 between September to October, whereas it decreased by only 0.03 with the bigger increasing number of participating organizations from October to November. In December when the remaining number of participating organizations was 171, the reachability increased to 0.28, which was higher than the October network composed of 178 participating organizations. The reachability of the December network is as high as the reachability of the September network (0.31).

The average geodesic length in the relief logistics network became longer when there are more participating organizations, but not necessarily in a linear relationship. From September (3.25) to October (3.57), the length of reachable paths increased by 0.32. From October (3.57) to November (4.31), the reachable paths became longer by 0.74. From November (4.31) to December (3.68), the reachable paths shortened by 0.63. Overall, the network evolution from September to October failed to develop an efficient network, as the reachability decreased with a longer geodesic distance. From October to November, the network evolved to remain reachable/connected even with a longer geodesic distance in a bigger network. From November to December, the network evolution effectively led to an increase in the reachability but with less focus on decreasing the average geodesic distance. Compared to the October network, the December network had 8 fewer participating organizations with a higher reachability by 0.08 consisting of longer reachable paths by 0.11.

The most notable change in the relief logistics network was the increase in individual organizations' access to efficient paths. In other words, the participating organizations figured out where to locate to obtain information and resources efficiently. From September to October, the average betweenness slightly decreased from 91.07 to 88.55, which means the

participating organizations had, on average, less access to the shortest paths within the network. In contrast, even with far more participating organizations in the network in November, the average betweenness dramatically increased up to 150.98. Even though individual organizations' access to shortcut paths decreased to 127.22 in December, the value was high during the operational period. The relief logistics network evolved toward a creation of reachable and efficient structure as a whole over the operational period.

6.3.2.2 Evolution trend in micro features of the network

Network resilience increases when organizations that serve different resources and functions effectively support one another, while several groups of organizations that serve the same or similar functions are loosely connected to replace one another in case of unexpected disturbances. The network resilience is measured by the extent of overlaps/distances among clusters. The relief logistics network shows decreasing propensity to create triadic closure among the participating organizations. From September to October, the triadic tendency increased from 0.17 to 0.21. In the later networks, the triadic tendency became weaker: 0.10 in November and 0.14 in December. Some empirical studies of networks in the real world found that when the greater the similarity within a group and the greater the difference between groups, the better or more distinct the clustering (Tan, Steinbach, & Kumar, 2013). In other words, a less distinctive trend of transitivity in the relief logistics network could be interpreted that the participating organizations continuously opened up toward other types of organizations. While participating organizations had narrowed down their perceptive differences or biases toward other organizations, they increased a sense of bonding by sharing the same vision and goal across organizational differences. As a result, the network evolved to create wider and open clusters, rather than small closed clusters.

Weak tie organizations significantly contribute to shaping the network into a less-fragmented structure by bridging and overlapping different clusters, eventually merging into open and bigger clusters in a network. To see the contributions of weak ties to develop resilient structure of the network, I went through three steps of analysis. First, I provided how many small clusters composed the entire network. The value of 4-steps clustering track indicates how many clusters can be created within four-step paths among neighboring organizations; when interactions among neighboring organizations within four-step paths are denser than the interactions with others, they are categorized as a cluster. The 2014 Ebola relief logistics network shows that as more organizations joined a network, the number of clusters increased. For instance, when additional forty-two organizations joined to the network between September to October, the number of clusters increased from 24 (density: 0.56) to 31 (density: 0.64). In November, the number of clusters further increased to 40 (density: 0.62). When almost 100 organizations left the network in December, the number of clusters decreased to 31 (density: 0.53).

Second, I showed the change in the proportions of weak ties in the network over the operational period. Interestingly, when the number of organizations participating in the relief logistics network increased, the proportions of weak tie organizations also increased. For instance, when the number of participating organizations rapidly increased in November, 81% of ties played a role as a bridging a cluster to another cluster. Compared to October (0.72), December had a higher proportion of weak ties (0.74) in the network even though the number of participating organizations was smaller. This phenomenon can be interpreted by two different possibilities. One possibility is that major coordinating organizations purposely recruited organizations that could serve as the bridge across different types of clusters. The other possibility is that participating organizations started to see benefits/advantages of getting new types of information and resources from different clusters, and then started to intentionally

change their positions as a weak tie by developing partnerships with different types of organizations over the operational period.

Third, I provided the number of communities. Communities indicate the number of larger clusters where neighboring but separated clusters got connected through weak ties. Weak ties played a critical role in creating communities by connecting separate clusters. In September, 24 separate clusters were re-grouped/ merged into 17 communities through weak ties. In October, 31 separate clusters were merged into 22 communities. In November, 40 separate clusters were merged into 24 communities. In December, 31 separate clusters were merged into 17 communities. The network evolved to be less fragmented over time even when the size of the network increased, as the boundary of interactions among organizations became extended. From September to October, when the number of the participating organizations increased by 42 new organizations, the number of 4 steps-distance clusters increased by 7 connected clusters. Meanwhile, the number of communities connected through weak ties increased by 5 clusters. Particularly from October to November when 92 new participating organizations created 5 more separate clusters in a 4 steps-distance, only two separate communities emerged from 22 to 24 communities. From November to December when 86 existing organizations left the network, the number of communities decreased by 7, resulting in 17 communities. Interestingly, the number of communities in the December network is the same with the September network, even though the December network has 35 more organizations than the September network. Comparing between October and December when the numbers of the participating organizations and the proportions of weak ties are similar, the number of communities in the December network (17 communities) was 5 less than the number in the October network (22 communities). These changes in the number of communities signify that the size of each community became bigger composing with many smaller and overlapped clusters.

6.4 Summary of the Network Evolving Trends

The operational environment changed dynamically along with unpredictable changes of the number of new affected cases throughout September to December 2014. In response to the rapidly changing situations, the relief logistics network kept adapting to develop an efficient and resilient network. The network evolved to respond to the changing needs by providing different organizational roles and operational levels within the relief logistics network to meet the current needs. The changes in priorities eventually drove changes of micro-and macro-features of the network, in turn, either increasing or decreasing efficiency and resiliency of information and resource flows. In other words, the changes of network structures play a critical role in enhancing the spill-over effect; direct and indirect benefits derived from organizational interactions can spread to surrounding areas wider and faster.

Each organizational function showed a different pattern of evolution in the network. The numbers of coordination and logistics service organizations in the network were very steady from the beginning to the end of the operational period. In contrast, donating and field operating organizations were relatively fluid in entering and exiting the network, because their participations in the network reacted to the number of affected cases in previous months. As the situation worsened, a surge of donor joined the network at the same time. When there were many donor organizations, field operating organizations also actively joined the network to receive grants from those donor organizations. When the situation stabilized, the majority of donor organizations left the network and the field operating organizations left consequently. Their fluid movements imply that many donor and field operating organizations usually joined for one-time participation. This implies that the response operation should not fully rely on the external resources from international donor organizations neither to meet immediate needs nor

to develop a long-term operational plan. Some interviewees pointed out the constraints of short-term basis resources from donating organizations.

The evolution of the network structure does not aim to create the shortest and the most resilient paths unlimitedly. If the benefit from the structure is higher than the cost to make further efforts to increase efficiency and resilience, the participating organizations would stop making such efforts. At the same time, even when a number of new organizations enter into the network, due to the nature of their interactions, the network diameter does not necessarily increase. Over the operational period, there were two major transition times: Between October and November and between November and December. The transition between October and November substantially increased the efficiency and resilience of the network, whereas the transition between November and December maintained the previous network structures with less participating organizations.

For example, the trend of transitivity directed to decrease over time in general. Transitivity is a strategic action to impose the security device in their relationships to avoid opportunistic behaviors. In October, a stronger triadic relational tendency decreased the efficiency of the entire network because a stronger triadic relational tendency lengthened the average betweenness by partitioning the network. In November, the triadic relational tendency substantially decreased, but in December, it marginally increased while keeping the resilient structure of the entire network. Also, the proportions of weak ties also did not unlimitedly increase over time even though its contribution to developing an efficient and resilient network. Rather, its increase stopped at a certain point.

These network features and evolving patterns provide substantial information to understand the changes of the performance of the relief logistics network. However, these features and evolving patterns do not provide any information of how those network features were established. It is very important to understand the network as whole along with

coordination mechanisms which lead structural changes of the network. Coordination as an evolving mechanism of a network serves a role in helping participating organizations to make better choices to adapt a new environment by providing timely information and reshaping their perceptions. For example, coordination can help organizations to avoid unnecessarily strong homophily partnerships within the same organizational roles and operational roles which partition the network. Coordination also makes a network stop an evolution in a stable situation. Understanding how and why coordination mechanism changed during these major transition times will provide more practical information to establish efficient and resilience collaboration structure. The following chapter will provide analysis of how a coordination process as a mechanism of network evolution changed over the operational period in comparison with the system performance during the Ebola crisis.

7.0 The Mechanism of the System Evolution: Exploitation Vs. Exploration

This research aims to analyze a system evolution process in response to the 2014 Ebola crisis during September through December in Liberia. During these four months, the number of affected cases rapidly increased and then rapidly decreased within a short time. These dynamic changes in the system signify the importance to understand how these system changes were derived. Chapters 5 and 6 present organizational and structural perspectives of the evolution process of a relief logistic network over the operational period. Every change in organizational partnership and network structure in the evolution process does not guarantee the improvement of the system performance. If participating organizations miss a critical piece of information to meet the particular needs embedded in a certain circumstance, they will misinterpret the situation and set wrong policy goals and objectives. In situations like this, the evolving direction of organizational partnerships and network structures is unfortunately misled, undermining the system performance. It is critical to pinpoint the mechanism which leverages the system to cross over the threshold which leads the system to rapid improvement.

Chapter 7 addresses the following question: what is the core coordination mechanism that drives the system changes: system evolution, degradation or stabilization? To be specific, chapter 7 aims to investigate the major change in the communication modes and the performance of those modes at the threshold of the system changes. The period between October and November 2014 showed a critical threshold in terms of the changes of the number of affected cases shown in Figure 9 (chapter 4). During this period, behavioral patterns at both an individual organizational level and a collaborative structural level also had distinctive changes. At an individual organizational level, participating organizations had a strong preference to find partners at the same operational level in October. This partnership trend, in turn, affected the entire network structure. The relief logistics network in October formed the

most fragmented inefficient structure characterized with the highest transitivity (closed clustering tendency) and the lowest average betweenness (the accessibility of a short-cut to resources and information) out of the entire operational period. In contrast, in November, participating organizations did not show a significant preference to find partners at the same operational level, but they showed the strongest preference within the same organizational roles (See details in chapter 5). The November network has the largest number of participating organizations. Nevertheless, the network structure became coherently connected with the highest efficiency—the lowest transitivity and the highest average betweenness— out of the entire operational period (See details in chapter 6). After this big change, the efficient features of the network structure have stabilized and there was the steady decrease of the number of affected cases in December.

To understand the mechanism to lead a big change and stabilize the system at both the organizational and structural levels of the relief logistics network, this chapter analyzes the changes of coordination mode between October, November, and December 2014. This chapter introduces 1) a theoretical framework of the evolution of coordination strategies, 2) communication modes as a key coordination mechanism, 3) thematic analysis and result, 4) co-occurrence analysis and result, and 5) conclusion.

7.1 The Evolution of Coordination Strategies: Exploitation Vs. Exploration

This section explains coordination strategies to improve the system performance in a fast-changing situation. The major coordinating organizations in a relief logistic network play a leading role in setting up the structure of a coordination process which helps participating organizations to identify resources and information required to adapt to a new situation. The diversity of resources and information obtained in a coordination process is substantially

determined by the diversity of participating organizations. Based on those obtained resources and information, the coordinating organizations set particular policy goals with implementation plans. The major coordinating organizations should carefully but also immediately figure out what types of organizations needs to be involved in a coordination process in response to a new situation. Within the constraints of time and existing capacities, the major coordinating organizations usually decide to invest more resources either to exploit the current strategies or explore new strategies.

Exploitation is defined as an organizational choice to strengthen the existing strategies and advantages in a system. Focusing on keeping the stability of the current status with minimal uncertainties, an exploitation strategy emphasizes reinforcing the existing capabilities and technologies and developing strict performance measurements to control quality (March, 1991). Major coordinators usually choose an exploitation strategy when the current strategy effectively works and there are not better alternatives. If the coordinating organizations in a relief logistic network emphasize maintaining the current stable system, they will put much effort to maximize the utility of existing skills and resources. This exploitation strategy works well in a stable and regular environment for a short-term. However, if a situation changes dynamically, the coordinating organizations need to immediately figure out the demands of new types of resources required to meet needs in the new environment. Without obtaining these new resources, the whole system will be endangered of degradation.

In contrast, exploration is defined as an organizational choice to expand and initiate new strategies to find new potential in a system. This strategy emphasizes exploring new information, resources and skills to seek new opportunities to create better performance in a new environment. This strategy requires replacing an existing routine with a new operating manner (Argyris, 1995). This strategy plays a critical role in increasing the resilience of the system surrounded by lots of random and sudden environmental changes (March, 1991, 1994),

such as the Ebola crisis. Working in a fast-changing situation surrounded by many uncertainties, the coordinating organizations in a relief logistics network should have strong capacity and skill to introduce an exploration strategy into an existing coordination routine. To be specific, the coordinating organizations need to obtain diverse information reflecting different perspectives of changing situations within the system. The narrow or limited understanding about situational changes among the participating organizations threatens to identify a problem incorrectly, which results in a misguided policy. A misguided policy will lead the system to fail to adapt to the new situation. To avoid this risk, a critical component of an exploration strategy is to expand the types of participating organizations and the diversity of information and resource pools in a coordination.

To exercise the exploration strategy, the coordinating organizations in the relief logistics network should serve a critical role in integrating new resources, ideas, and strategies into the existing coordination process. First, the coordinating organizations should immediately recognize the knowledge and resource gap between the existing system and changing environments, which is a 'structural hole' in the network. If they failed to fill this structural hole successfully, the entire group of participating organizations in the current system will misperceive the situation. This misperception makes the entire system remain a sub-optimal or inferior point in a moving landscape among multiple performance peaks. The coordinating organizations require sufficient capacity to figure out how to obtain new information and resources, and integrate these influxes of information and resource with the existing system. A successful adaptation of a relief logistics network requires both horizontal and vertical exchanges of information and resources constantly and simultaneously. The success of the horizontal and vertical coordination relies on the degree of involvement of the indispensable resources and actors who own these resources (Scharpf, 1997). Without a strong engagement of diverse organizations both within the same and across different operational levels, the EOC

could neither create a common operational picture to reflect comprehensive perspectives of on-going situations nor drive a collective action to realize the operational plan. However, the exploration coordination strategy creates a high degree of confusion, noise, errors, and conflicts against organizational resistance in the existing system (March, 1991, 1994). Incorporations of new types of organizations into the existing coordination process in a relief logistic network need an adjusting process between existing and new organizations. Even though a surrounding environment has changed, the existing coordinating organizations might want to keep the existing coordination routine due to inertial pressures (Hannan & Freeman, 1984) and path dependency (Pierson, 2000). The changes of existing organizations' routine coordinating process indicate that those existing organizations are willing to accept new ideas and logics into the current system. In the exploration strategy, it is very critical for the existing organizations to change the current manner even with unavoidable confusion and noise. New organizational members also need to make efforts to adapt and blend with not only the existing but also other new coming organizations in a coordination process.

7.2 Communication Modes as a Key Coordination Mechanism

Mutual trust is considered as a foundation to create a collective action (Hakanen & Soudunsaari, 2012). Communication plays a key role in increasing mutual trust by building a mutual learning process. In general, when people communicate with one another, they would likely perceive trust more than people who do not communicate. When their mutual trust increases, the probability of cooperation also increases (Loomis, 1959). Information and communication processes play an essential role in activating dynamics of the interactions (Smith, 2008). This interacting system allows participating organizations to learn about not only external situations but also interacting organizations. Their mutual understanding

developed through interactions generates a collective action and enables individual organizations to focus on a shared goal (Smith 2008).

Some communication decreases trust toward others, which undermines collaboration while increasing independent behaviors among people (Loomis, 1959). In a communication process, the information sent by a sender is not necessarily interpreted by receivers the same as how the sender intended, because there are many noises to distort intended messages in the information. These noises could come from external environments or from cognitive discrepancies between the sender and receiver. Participating organizations, as a social construct (Simon, 2019), have their own perceptions toward not only an external environment but also other participating organizations. A strong homophily preference could be a big barrier in an effective communication to build a collaboration based on mutual trust with other types of organizations. To exercise the exploration coordination strategy in response to a fast-changing situation, existing coordinating organizations should figure out effective communication modes to build mutual trust across different types of organizations.

Trust building is a relatively slow and long process, but it can be accelerated with good communication skills and modes (Sathle and Laento, 2000, referred from Hakanen & Soudunsaari, 2012). Communication modes, which characterize how to reach and create mutual interactions among participating organizations (Loomis, 1959), play a critical role in determining the extent of engagement of participating organizations into a coordination process. Depending on the communication tools, the level of interactions among participating organizations in coordination is set in the range from very impersonal to personal involvement. The information and knowledge flows are thus an outcome of the chosen communication tool as well as the characteristics of the communication process (Adenfelt, 2010). The coordinating organizations need to make constant efforts to adopt effective communication modes, which can increase mutual trust while decreasing cognitive discrepancies and organizational bias.

Information and knowledge that substantially contribute to increasing the system performance are distributed among multiple organizations, jurisdictions, and disciplines (Comfort, 2007b; Hutchins, 1995). The coordination should not only prioritize incoming information regarding changing conditions but also integrate it with known information about existing conditions so that participating organizations can adapt to a changing context for action internally and externally (Louise K. Comfort, Yeo, & Scheinert, 2019). Effective communication modes which not only convey information but also impose behaviors (Watzlawick, Bavelas, & Jackson, 2011) serve an essential role in leading to the success of a coordination. Without action-based changes to adapt to a new situation among participating organizations, the communication modes as a coordination manner fail to fulfill the goal of the coordination. In this case, the coordinating organizations need to find more effective communication modes to drive collective action.

The current coordination framework in response to an international crisis provides a very abstract picture of coordination process with very general advice. Little is known about how organizations successfully manage this critical process of recognizing environmental changes. To fill this gap between an international framework and a field experience, this chapter explores the specific coordination strategies and their performances to improve the quality of the system performance. To be specific, I argue that coordination strategies should be determined based on the quality of their collaboration performance, using comprehensive measurements. I will assess the coordination strategies based on not only particular communication modes used in a coordination process but also coordination performance changes derived by the changes of communication modes. Afterwards, I will show how these coordination strategies are related to the entire system performance.

7.3 Thematic Analysis

7.3.1 Research design

To assess the coordination strategies, first, I developed relevant measurements by identifying important themes and explore their relationships through iterative data reviews and analyses (Bennett & Checkel, 2015; Bennett & George, 1997). Based on traditional grounded theory, I conducted a thematic analysis for the semi-structured interviews to explore new themes and discover relations among those themes. I have repeatedly interpreted and (re)analyzed the interview data to find how participating organizations modified their coordination manners by using particular communication modes and how their performances changed accordingly. The analysis started from interview transcribing and processing the data from audio to text file. My first step of the analysis was to grasp a general context of the Ebola operations in the relief logistics network and to identify both common and distinctive ideas repeated across the set of respondents. Afterwards, I conducted an axial coding analysis using Atlas.ti software. I marked important concepts within the data. I revisited relevant information I had captured during the content analysis and compared those facts. After this validation process, I connected them with research questions. Finally, I drew emerging themes and categories through an iterative process of merging and demerging relevant concepts.

The analyses done in chapter 5 and 6 were driven by an inductive approach to apply existing theories into the coordination process during the Ebola crisis. In contrast, this chapter takes a deductive approach to explore potential to integrate different theories and discover relational patterns among those theories into a holistic framework. This deductive analytical process aims not only to elaborate the existing concepts with new findings but also to introduce an emerging framework synthesizing multiple theories. Furthermore, this analysis is very necessary to understand findings in chapters 5 and 6 as this analysis provides complementary

information of coordination mechanism. The analyses in chapters 5 and 6 were developed based on Relief Web documentary sources that missed critical perspectives in coordination with diverse Liberian organizations including local NGOs, even though they made substantial contributions during the response operation. This semi-structure interview data includes a wide range of Liberian organizations as well as important international organizations, and fills those missing gaps in the documents from ReliefWeb. This analysis will provide a more precise interpretation of how the system evolved along with the coordination mechanism changes.

7.3.2 Coding process

Figure 12 presents a coding sample which demonstrates a part of my coding process. I chose a coding sample that illustrates a coordination process where different organizations participated in a certain timeline. Based on this coding sample, I clarify how I analyzed content provided by an interviewee and categorized the content into relevant codes. The left side in Figure 12 shows the interviewer's question and the interviewee's answer. The interviewer and interviewee were identified with the initials of their names. The right side in Figure 12 shows how a selected content was coded.

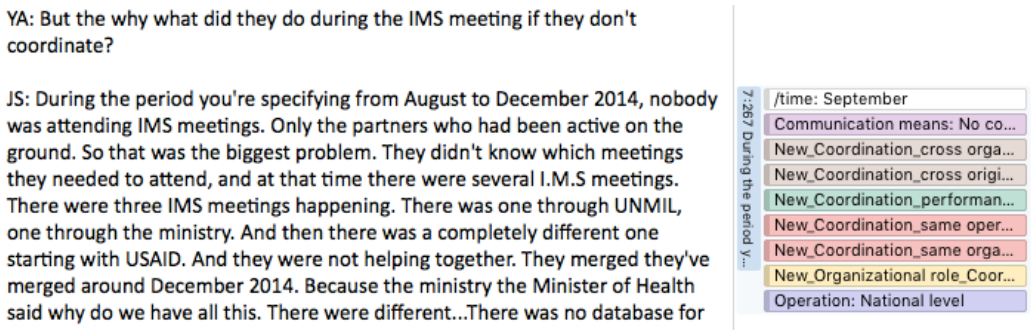


Figure 12 Coding Sample

To transform interview data into codes, I have gone through four steps. First, I identified and assorted the timelines of interviewee illustrations and grouped relevant information into a certain timeline. Because interviewees took a retrospective approach in

answering interview questions, their answers based on their memories might not be very precise in terms of a specific timeline. To identify the timeline as exact as possible in an interviewee's answer, I needed to rely on background knowledge gained through the content analysis and the facts presented by official documents in addition to information commonly captured by other interviewees. Shown in the above example in Figure 12, an interviewee stated that no unified coordination meeting (IMS) was established from August to December, which is contrary to the fact of the unified EOC's establishment in the middle of September. Nevertheless, this information illustrates situations that different types of organizations worked independently before the establishment of the unified EOC coordination meeting.

After identifying a specific timeline in an interviewee's answer, I categorized the types of organizational partnerships based on their interactions and their performances. This interview sample provided general information that showed multiple coordinating organizations had separate coordination meetings at a national level in the relief logistics network. Based on the interviewee's example of United Nations Mission in Liberia (UNMIL) and United States Agency for International Development (USAID), those coordination organizations came from different regions and from different organizational tiers. This information can be summarized as multiple coordinating organizations that came from different regions and different organizational tiers in the relief logistics network. In the September network, they served as coordinators at a national level, but they did not communicate with each other but worked independently. This whole chunk is coded as 1) Communication mode: no communication; 2) Partnership type: Cross organizational tier; 3) Partnership type: Cross original location; 4) Partnership type: same operational level; 5) Partnership type: same organizational role; 6) Organizational role: Coordinator; 7) Operation level: national level; 8) Coordination performance: defensive routine/ independent operation.

7.3.3 Issues of sample bias

The interview data coding and analysis could cause conceptual bias. If interview samples are selected exclusively from the same or similar types of organizations or if certain types of interviewees overly emphasized a particular phenomenon by spending a longer time to illustrate, their opinions could be over-weighted to discover conceptual relations. To avoid this bias risk, I divided the interviews into a certain timeline first as a big chunk, and then identified major coordination patterns overall within that timeline, rather than counting the mere number of words mentioned line by line. In my coding, even if an interviewee illustrated a certain coordination pattern where only certain organizations were involved for 100 minutes, this coordination pattern is coded once as long as the interacting organizations did not change in his/her illustrations. I also made efforts to avoid such issues during my interviews. I asked intervening questions to guide interviewees to share their coordination experiences with diverse types of organizations across operational levels in different operational timelines. As I presented the information of my interview data in chapter 3, my interview data from 34 organizational representatives well represents a wide range of organizational roles and operational levels from different original regions and organizational tiers. During the coding process, I discovered big differences in their coordination experiences depending on organizational roles and operational levels over the operational period. These big differences in interviewees' experiences substantially contributed to enriching a systematic comprehension by embracing multiple dimensions/perspectives of a coordination process. It also helps to sharply elaborate each concept with the common core factors across different perspectives.

7.3.4 Content analysis results: Emerging themes, categories, and sub-categories

Based on an iterative assessment of the interview and documentary data, I have developed three themes: Coordination components, Coordination strategies, and System performance. Each theme was further composed into categories, sub-categories, and sub-sub categories depending on its level of conceptualization. The first major theme coordination components consisted of three categories: organizational roles, operational levels of participating organizations, and major communication modes. Each category of coordination components is subdivided with specific information. Referring to chapter 5, organizational roles were identified as coordinator, relief logistics service, donor, military, ETU, field operator, communication service and community. The operational levels signifying the physical boundary in the relief logistics network in chapter 5 were identified with international, national, county, and community levels. Communication modes were specified ranging from personal to impersonal interactions; long-term regular communication, face-to-face, internal management system, telephone, E-mail, radio, official declarations, reports, and no communication.

The second theme, coordination strategy, was categorized by exploitation and exploration. Exploitation and exploration were determined by the quality of coordination performance among different types of organizations. To be specific, exploitation was divided into cross-partnership and passive collaboration, whereas exploration was divided into cross-partnership and active collaboration. Cross-partnership was further categorized with four different sub-sub categories: cross original locations, cross organizational tiers, cross organizational roles, and cross operational levels. Passive collaboration was further categorized by task adjustment, information exchange, defensive routine/independent operation, and

rejective attitude. Active collaboration was further categorized by full commitment/devotion, immediate response and collective situational awareness.

Lastly, system performance defined as adaptation to a changing environment was categorized between system degradation and system evolution. System degradation was determined when an interviewee signified the decreasing number of cases in a situation, whereas system evolution was determined when an interviewee signified the increasing number of cases in a situation. Table 17 illustrates the above information.

Table 17 Emerging Themes, Categories, and Sub-Categories

Theme	Category	Definitions	Subcategory	Sub-sub category	Notes
Coordination Components	**Communication means**	Interaction manners of participating organizations in a network	Long-term regular communication, face-to-face, Internal management system, telephone, E-mail, radio, official declarations, reports, no communications	N/A	From very personal communication to impersonal communication manners
	Organizational roles	Major duties of organizations serving in a network	Coordinator, Relief logistics service, Donor, Military, ETU, Field operator, Communication service, Community	N/A	
	Operational levels	Physical working level in a network	International level, National level, County level, Community level	N/A	Based on jurisdiction levels
Coordination Strategy: Exploration VS Exploitation	**Exploration**	Active collaboration in cross-partnership	Cross-partnership	Cross original locations	Interactions between organizations that came from different organizational locations (regions)
				Cross organizational tiers	Interactions between organizations that came from different organizational tiers (*organizaitonal tiers: International, regional, state, private, nonprofit)
				Cross organizational roles	Interactions between organizations that served different role in a network (*organizational roles: coordinator, logistics service, donor, military, ETUs, field operator, communication, community)
				Cross operational levels	Interaction between organizations that served in different operational levels (*operational levels: International, national, county, community)
			Active collaboration	Full commitment and devotion	Volunteerly providing services even before a request is made. More contributions beyond the request
				Immediate action	Taking an action right away after request
				Collective situational awareness	Adjusting different perceptions toward a certain issue or situation
	Exploitation	Passive collaboration in cross-partnership	Cross-partnership	Cross original locations	Interactions between organizations that came from different organizational locations (regions)
				Cross organizational tiers	Interactions between organizations that came from different organizational tiers (*organizaitonal tiers: International, regional, state, private, nonprofit)
				Cross organizational roles	Interactions between organizations that served different role in a network (*organizational roles: coordinator, logistics service, donor, military, ETUs, field operator, communication, community)
				Cross operational levels	Interaction between organizations that served in different operational levels (*operational levels: International, national, county, community)
			Passive collaboration	Task adjustment	Going through a bureaucratic process in response to a certain request
				Information exchange	Simply giving an objective information
				Defensive and independent routine	Negligence of a request or advice, and keeping an ordinary routine.
				Rejective attitude	Refusing a request with adverse attitudes
System Performance :Adaptation to a changing environment	**System Degradation**	The (rapid) increasing number of affected cases	N/A	N/A	N/A
	System Evolution	The (rapid) decreasing number of affected cases	N/A	N/A	N/A

7.4 Co-occurrence analysis

By applying these emerging themes and their relations I captured in the interview data, I explored 1) how communication modes changed in cross-partnership coordination and 2) how the coordination performance changed in cross-partnership accordingly throughout October, November, and December 2014. By comparing the changes of communication modes and the changes of coordination performance in cross-partnership, I determined particular coordination strategies in each month. To conduct these analyses, I used co-occurrence tables using Atlas-ti. The co-occurrence table counts the number when two codes are either coding exactly the same quotation or they are coding quotations that are overlapped or enclosed by each other. Through the frequency of co-occurrence between these two codes, those two codes are assumed to be associated in some way with each other (Contreras, 2011).

To relate the changes of communication modes and the changes of coordination performance in cross-partnerships, I went through three analysis processes. The first step of the analysis provides descriptive information to show a general trend in coordination components. This information shows what types of communication modes were popularly adopted by each organizational role and each operational level, respectively.

As the second step, I analyze the changes of communication modes adopted for coordination in cross-partnership. To capture the quality changes of communication modes in cross-partnership, I also provided the changes of communication modes adopted for coordination in homophily partnerships—organizations between same original regions, between same organizational tiers, between same organizational roles, and between same operational levels. Without the comparison of the differences of communication modes between homophily and cross-partnerships each month, I cannot tell how a coordination in cross partnership was changed qualitatively.

As the third step, I analyze the performance changes of coordination in cross-partnerships comparing to the performance changes of coordination homophily partnership over time. After all these analyses, I compared and related the changes of communication modes and coordination performances between homophily and cross partnerships over time. Based on these comparisons, I determined the coordination strategies adopted in each operational month.

7.4.1 Analysis Results

7.4.1.1 The changes of coordination components

This analysis highlights noteworthy findings which provide insight to understand the general communication trend in each month in Tables 18-20: how frequently each type of communication mode co-occurred with each organizational role and with each operational level, respectively. Within the category of organizational roles, there are 8 sub-categories. Within the category of operational levels, there are 4 sub-categories.

In October, according to organizational roles, the face-to-face communication mode (29%, 32 incidences) and no communication (27%, 30 incidences) were the most prevailing trends of the total communication incidences (112 incidences). The subcategories of coordinators and logistics service under the participating organizations had the highest incidences of face-to-face communications. Coordinators had 28% (9 incidences) of face-to-face communication mode, and logistics service organizations had 19% (6 incidences) out of 32 incidences. In contrast, coordinators and field operators had the highest incidences of no communication. Coordinators and field operators had 33% each (10 incidences for each role) of no communication, respectively, out of 30 incidences. According to the co-occurrence between the communication modes and operational levels, the face-to-face communication mode (27%, 23 incidences) and no communication (23%, 20 incidences) were the prevailing

trends out of the total communication incidences (86 incidences) across operational levels. The national level took the highest distribution (65%, 15 incidences) of face-to-face communication mode out of 23 incidences. The national (40%, 8 incidences), county (25%, 5 incidences) and community (35%, 7 incidences) levels had prevailing incidences of no communication out of 20 incidences.

In November, the adoption ratio of face-to-face communication mode substantially increased, whereas the adoption ratio of no communication substantially decreased. The long-term regular interactions became the second prevailing communication mode. The face-to-face communication mode and the long-term regular interactions took 57% (73 incidences) and 16% (20 incidences), respectively, of total communication modes (127 incidences) adopted by participating organizations. No communication took 12% (15 incidences) of total communication modes. Three organizational roles, including coordinators, field operators, and community, had the highest incidences of face-to-face communication modes. Coordinators took 30% (22 incidences) of face-to-face communication mode and field operators took 19% (14 incidences) of the face-to-face communication mode out of total 73 incidences. Community as a group of community residents had the highest distribution of face-to-face communication mode: 33% with 24 incidences. Community also had the highest distribution of long-term regular interactions: 35% (7 out of 20 incidences). According to the operational levels, a national level had less distribution of the face-to-face communication mode (30%, 16 out of 54 incidences,) compared to October. Meanwhile, the county (26%, 14 incidences) and community (43%, 23 incidences) levels had far increasing distributions of face-to-face communication mode compared to October. A community level also had the highest distribution of the long-term regular interactions (64%, 9 out of 14 incidences).

In December, the communication trend became stabilized, continuing the November communication trend. The face-to-face communication (56%, 73 out of 131 incidences) and

no communication (11%, 14 out of 131 incidences) maintained the steady level of adoptions by participating organizations, respectively. The long-term regular interaction mode was less adopted by participating organizations (11%, 15 out of 131 incidences). Two organizational roles, including coordinators and field operators, were the major roles that adapted the face-to-face communication mode. Coordinators took 25% (18 incidences) and field operators had 30% (22 incidences) out of total 73 incidences. Interestingly, these two organizational roles were also the major organizations that had the highest no communication trend. Coordinators and field operators took 50% (7 incidences) and 43% (6 incidences), respectively, out of the total 14 incidences. According to the operational levels, a national level had the highest distributions of face-to-face communication mode (38%, 18 out of 47 incidences). The county level relatively increased the adoption of face-to-face communication mode (30%, 14 incidences), whereas community levels relatively decreased the adoption of face-to-face communication mode (28%, 13 incidences) compared to November. A community level also had the highest distribution of the long-term regular interactions (45%, 5 out of 11 incidences). A national level had the highest distribution in no communication: 50% (4 out of 8 incidences).

Table 18 Coordination Components in October 2014

October (Total Quotes: 184)		Long-term regular interactions	Face to Face	Internal management system	Telephones	E-mail	Radio	Official declaration	Reports	No communication	Total
Organizational role	Coordinators	1	9	2	4	0	3	1	0	10	30
	Logistics service	4	6	2	2	0	0	0	0	1	15
	Donors	2	5	2	0	0	0	2	1	2	14
	Military	2	2	0	1	1	0	1	0	1	8
	ETUs	0	2	0	1	0	0	0	0	2	5
	Field operators	5	3	1	1	1	0	0	1	10	22
	Communication	0	0	0	0	0	0	0	0	0	0
	Community	4	5	0	1	1	3	0	0	4	18
	Total	18	32	7	10	3	6	4	2	30	112
	(Ratio)	0.16	0.29	0.06	0.09	0.03	0.05	0.04	0.02	0.27	1
Operational level	International level	2	1	3	0	0	0	1	1	0	8
	National level	3	15	3	5	1	3	2	0	8	40
	County level	1	2	0	1	0	0	1	1	5	11
	Community level	6	5	1	3	1	4	0	0	7	27
	Total	12	23	7	9	2	7	4	2	20	86
	(Ratio)	0.14	0.27	0.08	0.10	0.02	0.08	0.05	0.02	0.23	1

Table 19 Coordination Components in November 2014

November (Total Quotes: 162)		Long-term regular interactions	Face to Face	Internal management system	Telephones	E-mail	Radio	Official declaration	Reports	No communication	Total
Organizational role	Coordinators	1	22	1	3	0	1	2	0	4	34
	Logistics service	4	3	2	1	0	0	0	0	1	11
	Donors	2	6	2	0	0	0	2	1	2	15
	Military	1	1	0	0	0	0	0	0	1	3
	ETUs	0	2	0	0	0	0	0	0	0	2
	Field operators	5	14	1	0	0	0	0	1	6	27
	Communication	0	1	0	0	0	0	0	0	0	1
	Community	7	24	0	1	0	1	0	0	1	34
	Total	20	73	6	5	0	2	4	2	15	127
	(Ratio)	0.16	0.57	0.05	0.04	0.00	0.02	0.03	0.02	0.12	1
Operational level	International level	2	1	1	0	0	0	1	1	0	6
	National level	2	16	3	3	0	1	1	0	3	29
	County level	1	14	0	1	0	0	0	1	2	19
	Community level	9	23	0	3	0	1	0	0	2	38
	Total	14	54	4	7	0	2	2	2	7	92
	(Ratio)	0.15	0.59	0.04	0.08	0.00	0.02	0.02	0.02	0.08	1.00

Table 20 Coordination Components in December 2014

December (Total Quotes: 117)		Long-term regular interactions	Face to Face	Internal management system	Telephones	E-mail	Radio	Official declaration	Reports	No communication	Total
Organizational role	Coordinators	1	18	2	1	0	2	1	0	7	32
	Logistics service	4	9	6	2	1	0	0	1	0	23
	Donors	3	12	3	0	0	0	1	2	1	22
	Military	0	0	0	0	0	0	0	0	0	0
	ETUs	0	3	0	0	0	0	0	0	0	3
	Field operators	4	22	1	0	0	1	0	2	6	36
	Communication	0	0	0	0	0	0	0	0	0	0
	Community	3	9	0	0	0	3	0	0	0	15
	Total	15	73	12	3	1	6	2	5	14	131
	(Ratio)	0.11	0.56	0.09	0.02	0.01	0.05	0.02	0.04	0.11	1.00
Operational level	International level	2	2	2	0	0	0	1	1	2	10
	National level	3	18	3	4	1	3	1	1	4	38
	County level	1	14	5	3	1	0	0	1	0	25
	Community level	5	13	0	1	0	2	0	1	2	24
	Total	11	47	10	8	2	5	2	4	8	97
	(Ratio)	0.11	0.48	0.10	0.08	0.02	0.05	0.02	0.04	0.08	1.00

7.4.1.2 Communication modes in coordination based on types of partnerships

Tables 21, 22, and 23 summarize the changes of communication modes to coordinate homophily and cross partnerships, respectively, in October, November and December of 2014. This analysis highlights noteworthy findings which provide insight to understand the differences of the communication modes between homophily and cross partnerships: how frequently each type of communication mode co-occurred with homophily partnerships and with cross partnerships, respectively. Within the sub-category of homophily and cross partnerships, there are 4 sub-sub categories.

In October, homophily partnerships used personalized communication modes in their coordination: face-to-face communication (39%, 41 out of 106 incidences) and long-term regular interactions (27%, 29 out of 106 incidences). In contrast. the cross partnerships utilized two extreme types of communication modes, either face-to-face communication (28%, 40 out of 141) or no communication (25%, 35 out of 141 incidences).

In November, both homophily and cross partnerships actively increased the face-to-face communication mode in coordination. The homophily partnerships used the face-to-face communication (58%, 69 out of 118 incidences) much higher than October and steadily used the long-term regular interactions as the second popular communication mode (27%, 32 out 118 incidences). The cross partnerships also substantially increased face-to-face communication mode (56%, 85 out of 151 incidences), reaching to the level of the adoptions within homophily partnerships. Consequently, the face-to-face communication mode became the most prevailing coordination manner in coordination within cross partnerships. Meanwhile, cross-partnerships coordination far decreased no communication trend (13%, 20 out 151 incidences) compared to October, but the level of no communication in the cross partnerships was still much higher than in homophily partnerships (3%, 3 out of 118 incidences).

In December, the face-to-face communication mode was adopted as the most popular coordination manner both in homophily and cross partnerships, continuing the trend of November. Homophily partnerships adopted the face-to-face communication mode little less (47%, 62 out of 133 incidences) than the ratio of November. Homophily partnerships started to use an internal management system in their coordination as the second major communication modes (17%, 22 out 133 incidences). The long-term regular interactions within homophily partnerships decreased (17%, 22 out of 133 incidences) compared to October and November (27%). Cross partnerships steadily used the face-to-face communication mode (56%, 98 out of 175 incidences) in their coordination as active as in November (56%). The adoptive ratio of the face-to-face communication modes in cross partnerships became higher than the adoption in homophily partnerships. No communication tendency in cross partnerships steadily continued (14%, 25 out of 175 incidences) without a big change compared to November.

The adoption patterns of the communication modes were different between homophily and across partnerships. Homophily partnerships utilized two personal communication modes for October and November as major coordination manners: the long-term regular interactions and face-to-face communication modes. Particularly in November, homophily partnerships increased the adoption of the face-to-face communication mode by 19% (from 39% in October to 58% in November), while maintaining the same adoption level of the long-term regular interactions, 27%. In December, they diversified communication modes by using IT infrastructure which is internal management system (17%), but they decreased the adoptions of the face-to-face communication to 47% and the adoptions of the long-term regular interactions 17%. In contrast, across partnerships steadily utilized the adoption of the face-to-face communication mode in December after they reached to the highest utilization in November

Table 21 Communication Modes in Homophily and Cross Parternships in October 2014

October		Long-term regular interactions	Face to Face	Internal management system	Telephones	E-mail	Radio	Official declaration	Reports	No communication	Total
Homophily Partnership	Same operational levels	9	17	1	2	2	0	0	0	2	33
	Same organizational roles	5	11	2	1	1	0	0	0	0	20
	Same organizational tier	8	9	2	3	1	0	2	0	0	25
	Same original regions	7	4	2	5	2	2	0	0	6	28
	Total	29	41	7	11	6	2	2	0	8	106
	(Ratio)	0.27	0.39	0.07	0.10	0.06	0.02	0.02	0.00	0.08	1.00
Cross Partnership	Cross operational levels	3	5	4	6	1	2	2	2	9	34
	Cross organizational roles	6	14	3	7	2	2	2	1	11	48
	Cross organizational tiers	4	11	2	4	2	2	0	1	11	37
	Cross original regions	2	10	2	1	1	0	2	0	4	22
	Total	15	40	11	18	6	6	6	4	35	141
	(Ratio)	0.11	0.28	0.08	0.13	0.04	0.04	0.04	0.03	0.25	1.00

Table 22 Communication Modes in Homophily and Cross Partnerships in November 2014

November		Long-term regular interactions	Face to Face	Internal management system	Telephones	E-mail	Radio	Official declaration	Reports	No communication	Total
Homophily Partnership	Same operational levels	9	24	1	1	0	0	0	0	1	36
	Same organizational roles	7	15	0	1	0	0	0	0	0	23
	Same organizational tier	9	12	2	2	0	0	2	0	0	27
	Same original regions	7	18	1	3	0	1	0	0	2	32
	Total	32	69	4	7	0	1	2	0	3	118
	(Ratio)	0.27	0.58	0.03	0.06	0.00	0.01	0.02	0.00	0.03	1.00
Cross Partnership	Cross operational levels	3	16	2	3	1	1	2	1	5	34
	Cross organizational roles	6	27	3	3	1	1	2	1	6	50
	Cross organizational tiers	4	25	0	2	1	1	0	1	6	40
	Cross original regions	3	17	1	0	1	0	2	0	3	27
	Total	16	85	6	8	4	3	6	3	20	151
	(Ratio)	0.11	0.56	0.04	0.05	0.03	0.02	0.04	0.02	0.13	1.00

Table 23 Communication Modes in Homophily and Cross Partnerships in December 2014

December		Long-term regular interactions	Face to Face	Internal management system	Telephones	E-mail	Radio	Official declaration	Reports	No communication	Total
Homophily Partnership	Same operational levels	7	26	2	0	0	0	0	0	2	37
	Same organizational roles	4	11	7	3	1	1	0	1	1	29
	Same organizational tier	6	11	6	3	1	2	0	1	1	31
	Same original regions	5	14	7	3	1	3	0	1	2	36
	Total	22	62	22	9	3	6	0	3	6	133
	(Ratio)	0.17	0.47	0.17	0.07	0.02	0.05	0.00	0.02	0.05	1.00
Cross Partnership	Cross operational levels	3	13	7	4	1	3	1	3	6	41
	Cross organizational roles	5	29	3	1	0	2	1	2	7	50
	Cross organizational tiers	4	30	1	1	0	1	1	2	7	47
	Cross original regions	3	26	0	0	0	0	1	2	5	37
	Total	15	98	11	6	1	6	4	9	25	175
	(Ratio)	0.09	0.56	0.06	0.03	0.01	0.03	0.02	0.05	0.14	1.00

7.4.1.3 Coordination performance based on the types of partnerships

Tables 24, 25, and 26 show comparative pictures of the changes of coordination performance according to the types of partnerships, in October, November and December of 2014. This analysis highlights noteworthy findings which provide insight to understand the differences of the communication modes between homophily and cross partnerships: how frequently each type of communication mode co-occurred with homophily partnerships and with cross partnerships, respectively. Within the sub-category of homophily and cross partnerships, there are 4 sub-sub categories. The coordination performance is divided into two sub-categories: Active and passive collaborations. The active collaboration sub-category that characterizes positive interactions involves full commitment/devotion, immediate response, and collective situational awareness. The passive collaboration sub-category that characterizes negative interactions involves task adjustment, information exchange, defensive routine/independent operation, and rejective attitude.

In October, the coordination performance within homophily partnerships was assessed as active collaboration in terms of full commitment/devotion (14%, 15 out of 108 incidences), immediate response (25%, 27 incidences), and collective situational awareness (21%, 23 incidences). At the same time, their performances were also assessed passively in some extent: Defensive routine/ independent operation (16%, 17 incidences) and rejective attitude (11%, 12 incidences). The coordination performance within cross partnerships was more passively assessed compared to the performance in homophily partnerships: task adjustment (15%, 23 out of 158 incidences), defensive routine/independent operation (32%, 50 incidences), and rejective attitudes (18%, 28 incidences). Meanwhile, the coordination performance within cross partnerships also had some positive assessment with immediate responses (15%, 24 out of 158 incidences).

In November, the coordination performances were improved both within homophily and cross partnerships. The coordination performances in homophily partnerships were very positively assessed as immediate response (47%, 62 out of 133 incidences) and collective situational awareness (38%, 50 incidences). The negative performance including defensive routine/independent operation (3%, 4 incidences) and rejective attitude (3%, 4 incidences) markedly decreased. The coordination performances within cross partnerships were very positively assessed as immediate response (31%, 49 out 158 incidences) and collective situational awareness (25%, 40 incidences) compared to October, but the levels of these positive assessments were still lower than the performance level of homophily partnerships. Meanwhile, the negative performances within cross partnerships noticeably decreased: Defensive routine/independent operation (15%, 23 incidences) and rejective attitude (7%, 11 incidences). Task adjustment within cross partnerships' coordination was steadily found as before: 14 % (22 incidences).

In December, the coordination within homophily partnerships steadily showed an active collaboration with immediate response (39%, 61 out of 155 incidences), collective situational awareness (30%, 46 incidences), and full commitment/devotion (12%, 18 incidences) to one another. Meanwhile, somewhat passive response within homophily partnerships including information exchange (6%, 9 incidences) marginally increased. The coordination within cross partnerships maintained the steady level of positive performance with immediate response (27%, 72 out of 262 incidences) and collective situational awareness (27%, 72 incidences). The coordination performance moved from a passive to an active direction of collaboration. While the defensive routine/independent operation (11%, 29 incidences) and rejective attitude (3%, 8 incidences) marginally decreased, slightly improved performance including information exchange (13%, 34 incidences), was signified. Task

adjustment within cross partnerships' coordination was steadily found as before: 16 % (41 incidences).

Table 24 Coordination Performance in Each Type of Partnerships in October 2014

October (Total Quotes: 184)	Category	Full commitment/ devotion	Immediate response	Collective situational awareness	Task adjustment	Information exchange	Defensive routine/ Independent operation	Rejective attitude	Total
Homophily Partnership	Same operational levels	4	7	10	3	0	6	3	33
	Same organizational roles	3	7	7	2	1	3	1	24
	Same organizational tier	4	7	4	2	1	1	1	20
	Same original regions	4	6	2	3	2	7	7	31
	Total	15	27	23	10	4	17	12	108
	(Ratio)	0.14	0.25	0.21	0.09	0.04	0.16	0.11	1.00
Cross Partnership	Cross operational levels	2	5	2	6	5	11	7	38
	Cross organizational roles	3	7	3	7	4	14	9	47
	Cross organizational tiers	2	6	4	6	3	16	9	46
	Cross original regions	1	6	3	4	1	9	3	27
	Total	8	24	12	23	13	50	28	158
	(Ratio)	0.05	0.15	0.08	0.15	0.08	0.32	0.18	1.00

Table 25 Coordination Performance in Each Type of Partnerships in November 2014

November (Total Quotes: 162)	Category	Full commitment/ devotion	Immediate response	Collective situational awareness	Task adjustment	Information exchange	Defensive routine/ Independent operation	Rejective attitude	Total
Homophily Partneship	Same operational levels	2	16	14	1	0	2	1	36
	Same organizational roles	2	15	13	1	0	2	0	33
	Same organizational tier	3	13	10	1	0	0	0	27
	Same original regions	2	18	13	1	0	0	3	37
	Total	9	62	50	4	0	4	4	133
	(Ratio)	0.07	0.47	0.38	0.03	0.00	0.03	0.03	1.00
Cross Partnership	Cross operational levels	2	10	9	7	2	5	3	38
	Cross organizational roles	2	16	10	6	2	5	3	44
	Cross organizational tiers	1	14	12	5	2	7	4	45
	Cross original regions	1	9	9	4	1	6	1	31
	Total	6	49	40	22	7	23	11	158
	(Ratio)	0.04	0.31	0.25	0.14	0.04	0.15	0.07	1.00

Table 26 Coordination Performance in Each Type of Partnerships in December 2014

December (Total Quotes: 117)	Category	Full commitment/ devotion	Immediate response	Collective situational awareness	Task adjustment	Information exchange	Defensive routine/ Independent operation	Rejective attitude	Total
Homophily Partnership	Same operational levels	5	20	13	2	1	5	0	46
	Same organizational roles	4	11	10	1	2	3	1	32
	Same organizational tier	5	13	10	2	3	1	1	35
	Same original regions	4	17	13	2	3	1	2	42
	Total	18	61	46	7	9	10	4	155
	(Ratio)	0.12	0.39	0.30	0.05	0.06	0.06	0.03	1.00
Cross Partnership	Cross operational levels	1	12	17	10	10	5	3	58
	Cross organizational roles	2	24	19	11	9	7	2	74
	Cross organizational tiers	1	20	20	10	8	9	2	70
	Cross original regions	2	16	16	10	7	8	1	60
	Total	6	72	72	41	34	29	8	262
	(Ratio)	0.02	0.27	0.27	0.16	0.13	0.11	0.03	1.00

7.5 Conclusion: Coordination Mechanism Changes

This chapter aims to analyze the evolution trend of coordination between exploitation and exploration strategies. To be specific, a particular coordination strategy is determined by comparing analysis results horizontally and vertically. The horizontal analysis signifies the differences of popular communication modes and the differences of coordination performances between homophily and cross partnerships in the same month. The vertical analysis signifies the changes of popular communication modes and the changes of coordination performances in each type of partnerships cross the operational periods throughout Oct, Nov, and December of 2014.

The October coordination is characterized with an exploitation strategy. Even though the face-to-face communication mode was the most popular coordination manner in coordination for both homophily and cross partnerships, the October coordination was basically a lack of face-to-face communication within both partnerships compared to later months. Also, the quality of the face-to-face coordination was very low in that defensive routine/independent routines and rejective attitudes were quite high not only in cross partnerships but also in homophily partnerships. Furthermore, the gap of using the face-to-face modes between homophily and cross partnerships was relatively big (39% Vs. 28%), and no communication tendency was much more prevailing within cross partnerships (25%) compared to homophily partnerships (8%). Also, the gap of coordination performances between homophily and cross partnerships was quite distinctive. The coordination performance within homophily partnerships was assessed with 60% active collaboration (total sum of each ratio of full commitment/devotion, immediate response, and collective situational awareness) and 40% passive collaboration (total sum of each ratio of task adjustment, information exchange,

defensive routing/independent operation, and rejective attitude). The coordination performance within cross partnerships was assessed with 28% active collaboration and 72% passive collaboration. This result signifies an exploitation coordination strategy tendency clearly that a major coordination system failed to utilize active coordination manners to engage and incorporate new information and resources from diverse types of organizations. The coordination performance within cross partnerships showed the failure to create collaboration among diverse organizations in a full extent. Reflecting to March's argument (1991, 1994), this exploitation strategy was not fit to deal with a rapidly changing environment, surging the number of affected cases. This mismatch between the coordination strategy and the system status is assumed to degrade the system (system degradation) with a surging number of affected cases.

In response to this degrading system, the November coordination started to exercise an exploration strategy. The November coordination increased the face-to-face communications both within homophily and cross partnerships. Particularly, the adoption of the face-to-face communications within cross partnerships (56%) was as almost as high as the adoption within homophily partnerships (58%). Also, the coordination performances within both homophily and cross partnerships noticeably increased in that active collaboration increased and passive collaboration decreased. The coordination performance within homophily partnerships was assessed with 92% active collaboration and 8% passive collaboration. The coordination performance within cross partnerships was assessed with 60% active collaboration and 40% passive collaboration. However, the gap of coordination performances between homophily and cross partnerships maintained the same level as the October performance gap between homophily and cross partnerships; 32% is higher in active collaboration of homophily partnerships than of cross partnerships in October and November. This result signifies an exploration coordination strategy tendency clearly that a major coordination system increased

to utilize active coordination manners to engage diverse types of organizations. The coordination performance within cross partnerships also showed much improved collaboration among diverse organizations. As March (1991) emphasized, this exploration coordination strategy played a critical role in adapting to a fast-changing environment in November, leading a system evolution.

When the system entered into a stable status with decreasing number of affected cases, the December coordination exercised an exploitation strategy. The December coordination maintained active adoptions of the face-to-face communication mode in both homophily (47%) and cross (56%) partnerships. Interestingly, cross partnerships adopted the face-to-face communication mode more actively than homophily partnerships. The coordination performances decreased in both homophily and cross partnerships compared to November. The coordination performance within homophily partnerships was assessed with 81% active collaboration and 19% passive collaboration. The coordination performance within cross partnerships was assessed with 57% active collaboration and 43% passive collaboration. However, the gap of coordination performances in an active collaboration between homophily and cross partnerships decreased from 32% in November to 24% in December. This result signifies an exploitation coordination strategy tendency clearly that a major coordination system focused on strengthening previous coordination manners and maintaining, not increasing, the optimal performance, because the system was already in a stable status with steadily decreasing affected cases.

Based on the coordination trend over time, it took a longer time for cross partnerships to increase their coordination performance even though the cross partnerships actively adopted the face-to-face communication mode in November and December. Also, a task adjustment was steadily found within cross partnerships throughout time between 14-16%. A task adjustment collaboration reflects a slow response to follow an organizational hierarchical

order. The hierarchical order serves as a safeguard to reduce transaction costs in coordination as this order clarifies the person in charge and his/her responsibility in detail. It indicates that building mutual trust within cross partnerships is more difficult than within homophily partnerships. The cross-partnership coordination requires more elaborate communication skills that facilitate the face-to-face communication more effectively.

Another interesting finding is that a remote coordination has lots of challenges to improve the coordination performance even within homophily partnerships. Using IT infrastructure, an internal management system was introduced to coordinate inventory management within logistics service organizations between national and county levels in December when Forward Logistics Bases (FLBs) started to operate at a county level (Table 18). Even though logistics service organizations who worked together over the operational period already shared the common operational picture, this remote communication limited the quality of the coordination. This coordination difficulty derived a minimal increase in a slow performance: information exchange within homophily partnerships in December.

" ...the inventory was reported only by the local staff, not very often national staff going to check whether inventory is really correct or not. As you know the difficulties, because of the distance..." (Interviewee 3, a national manager from the Liberian Ministry of Health)

This remote coordination experience within a homophily partnership signifies the importance to narrow down perceptive gaps caused by physical distances to improve the performance. Even after sharing the same operational picture, physical differences create lots of perceptive gaps because a surrounding situation keeps changing. To reduce those perceptive gaps, the face-to-face coordination mechanism should serve as a fundamental coordination manner to narrow perceptive gaps constantly. Nowadays, many organizations prefer to replace face-to-face communications with IT based communication modes for the communication

efficiency. This IT-based remote communication could work effectively among the organizations that share similar perceptions in stable and regular operations. However, during a crisis when diverse types of organizations need to adjust their perceptive gaps constantly, those remote communications solely using IT means undermine their collaboration by failing to reduce perceptive gaps. The IT-based communication should be adopted as a subsidiary mean in addition to a well-established face-to-face coordination manner.

8.0 Conclusion

This research started with a general question of what conditions drive a system evolution to adapt to a complex situation successfully. To address this general question, this research decomposed the system evolution process into individual and collective levels. This research specifically analyzed an individual organizational behavioral mechanism (tendency), a process of their behavioral changes through coordination, and the impact of organizational behavioral changes on the entire structure of collaboration as whole. The coordination strategies——exploitation and exploration—serve as a key mechanism to guide or change an individual organizational behavioral mechanism in a way to increase organizational adaptation to internal and external environments. The changes of organizational behavioral mechanisms, in turn, change the features of the collaboration structure determining the efficiency and resilience of information and resource flows. For this reason, this research argues that coordination strategies should be considered as a key mechanism to determine either system evolution or system degradation. The fitness of coordinating strategies should be assessed along with the environmental characteristics in the system. While exploitation fits to a stable and regular environment, exploration fits to a dynamic changing environment in a system. This research carefully related applied coordination strategies with environmental changes during a certain operational period, and assessed whether the adopted coordination strategy led to evolve, degrade, or stabilize the system. By tracing those evolution tracks in an extended timeline, this research could identify the threshold when the system evolution was driven with particular conditions. By incorporating individual analysis results provided in previous chapters, this chapter seeks to draw in-depth understanding of theoretical and practical implications derived from a complementary and comprehensive perspective. Finally, this

chapter draws out theoretical, methodological and practical contributions for future research directions.

8.1 The Relief Logistics Network During the 2014 Ebola Crisis in Liberia

The relief logistics network plays a crucial role in strengthening the entire response operation by supporting field operations with critical resources. When a relief logistics network is supported with an efficient system to exchange information and to transmit resources, the network serves as a backbone of the entire operation. Its performance ultimately contributes to minimizing damages during a crisis. However, due to environmental challenges interacting with the characteristics of a crisis in the field, it is very challenging to establish such an effective relief logistics network immediately. The relief logistics network in response to the 2014 Ebola crisis in Liberia was set up in a very complex situation where people suffered from chronic malnutrition with marginal access to health and transportation infrastructures. It was not predictable for where the next target communities of the Ebola virus would be because affected people started to hide and escape from the government surveillance system. As the response operation was extended going through a heavy rainy season, resource management and transmission became more complex with limited storage capacities and worsening conditions of transportation infrastructure.

In addition to these external environmental complexities, a huge influx of participating organizations that had different organizational attributes made the working condition of the relief logistics network even more complex. Participating organizations from different regions with different experiences brought different perceptions, goals, and plans into the network. As the relief operation was extended, those participating organizations did not steadily participate in a coordination process. Major coordinating organizations could expect neither what kinds of

organizations would join nor how long those organizations would stay. Some organizations left and came back in the middle of the operation, and some other organizations joined in the last stage of the operation. Because of these unpredictable conditions in a coordination process, the internal coordination environment of the relief logistics network made more challenges for the participating organizations to create a collective action in a coherent manner.

A relief logistics network requires well-prepared plans based on a comprehensive understanding of both internal and external conditions that affect its operational performance. Many research studies in the field of relief logistics system place much emphasis on developing advanced techniques to increase the predictability of environmental conditions and the efficiency of resource and transportation management. This approach would be helpful to deal with uncertainties from external conditions. In contrast, there is a huge lack of quantitative and qualitative research discussing the complexity of internal conditions of the relief logistics network. This shortage resulted in repeated failures to create collective action in a timely manner in a relief logistics network involving diverse organizations from around the world.

To meet the current needs, the purpose of this research is to make a step forward to understand the complexity of internal mechanisms of the relief logistics network. We need to understand what the real meaning of a well-prepared relief logistics system is. The flow of resources is not a technically automatic movement of resources based on a fixed schedule. Rather, the resource flow is the final result/manifestation of the organizational collaboration driven by coordination among the participating organizations. Well-prepared relief logistics does not mean solely building a highly advanced technical system, even though a technical system is necessary. Organizations do not work according to ideal plans and schedules suggested by this advanced technical system. Individual organizations are social entities that have their own desires, goals, and plans. Technical management doesn’t work until these different participating organizations are successfully coordinated and adjusted accordingly by

sharing the common goal. In other words, an agile and flexible relief logistics network depends on how much participating organizations are flexible and willing to change their routine operations to adapt to not only environmental needs but also partner organizations. The real meaning of well-preparedness of the relief logistics network is to plan coordination strategies by understanding and reflecting on the operational requirements for an organizational behavioral mechanism in a complex environment.

8.2 Coordination: A Process of Creating New Rules in Adapting to a New Environment

The successful operation of a relief logistics network is made through both horizontal and vertical collaborations to transmit information and resources simultaneously. Necessary information and resources should flow through a wider range of networks without structural holes. To create such network, participating organizations need to work with the 'right' partner organizations that can provide complementary resources and information to support and achieve individual and collective goals. However, organizational perceptions of 'right' or 'favorable' partners are substantially influenced by external environments. In other words, their perceptions also change according to the environmental changes. The challenges of coordination caused by organizational perceptions toward other participating organizations should be understood based on particular working conditions. This section illustrates how organizational behavioral tendency to find 'right' partners change according to the internal environmental changes led by coordination strategies in the network.

8.2.1 First challenge: Organizational homophily propensity based on existing rules

The first challenge of the coordination is to overcome a strong organizational tendency to rely on existing organizational rules in the new environment. When a working environment is very unfamiliar both internally and externally, organizations try to find partner organizations in a way to avoid, rather than take, risks. The Ebola outbreak was much more uncertain compared to other previous disasters. Almost all participating organizations had neither responded to epidemic outbreaks nor worked in Liberia. These participating organizations had no idea what kinds of roles they would serve in the field. Also, there were no rules or external clues to indicate what kinds of organizations would be good partners for each one of them. To minimize uncertainties caused by potential partners in response to a fast-changing situation, these organizations took an exploitation strategy, relying on their existing rules including formal and informal institutions to calculate the transaction costs, rather than an exploration strategy to develop a new rule by obtaining new information embedded in a new environment.

As illustrated in Table 15 in chapter 5, original regions and organizational tiers played roles of the most effective indicators in developing organizational partnerships in September 2014. Those institutional attributes imply that existing informal rules including regional and organizational cultures and organizational operational norms. Even after joining in a new coordination system in a new environment in Liberia, the participating organizations tried to find partners referring to those existing rules, rather than new operational rules in the network including organizational roles and operational levels. The organizations perceived other organizations that shared the same norms and cultures as favorable partners to collaborate because those shared internal values could minimize costs in coordination effectively even with their routine manners. The organizations' strong path dependency caused them to take an exploitation strategy to adapt to a new environment. This exploitation strategy resulted in

creating separate clusters exclusively consisting of the same types of organizations in a network. Within a cluster, they could perceive that their coordination is very efficient and effective with less troubles and conflicts. However, this strong homophily tendency formed closed clusters disconnected with other clusters, shaping a segmented structure of the network as a whole.

8.2.2 Second challenge: Organizational homophily tendency within the same organizational roles and operational level

When organizations started to get familiar to new environments and other participating organizations in October, they started to find new partners that were physically accessible. Under the UN cluster coordination framework, participating organizations that have the similar expertise and skills are grouped as a cluster to serve a particular function in a general operation plan. This approach is helpful for participating organizations to quickly figure out what they can serve and which organizations are the potential partners within the cluster. However, it creates another homophily rule among participating organizations when finding partners, that is, clinging to the same role at the same operational level. As this coordination framework focuses on developing a national coordination system, only organizations that operate at the national level can have wider physical accessibility to know one another. As a result, this current cluster coordination framework strengthens the horizontal collaboration exclusively within the same roles at a national level.

In contrast, the successful collaboration in a relief logistics network should involve both horizontal and vertical collaboration. The current cluster approach endangers participating organizations by isolating their view by focusing on horizontal collaboration narrowly, rather than focusing on the entire operational perspectives. Reports of coordination in October 2014 show this second challenge of coordination in the field. Referring to Table 15 in chapter 5, the

participating organizations had strong propensity to find partners that worked at the same operational level in addition to ones that shared the common values from the same organizational tiers and original locations. This statistical result implies that the organizations started to recognize the importance of creating a collaboration within the same role and at the same operational level to adapt to new working environments. However, this statistical result should be understood with other qualitative perspectives in the internal coordination environment. During October, even though the distribution of the participating organizations in a community increased as well as at the national level (referring to Figure 11 in chapter 6), the face-to-face coordination occurred exclusively at the national level without communication at county and community levels (referring to Table 19 in chapter 7). Also, face-to-face coordination at a national level was recognized only for coordinating organizations and logistics service organizations (referring to Table 19 in chapter 7). In fact, these two organizational roles consisted exclusively of international governance organizations and the Liberian government. This fact signifies that except international governance organizations and national governments, no other types of organizations from different organizational levels and tiers were involved in the coordination process, even if those organizations worked at a national level. This October coordination picture represents a very strong exploitation coordination within the international and national coordinating organizations at the national EOC, which reflects the current cluster coordination framework.

This strong exploitation coordination created a highly segmented and vulnerable collaboration structure in the entire logistics network. Without information and resource flow across national, county, and community levels, there were two separate parallel systems between upper and lower jurisdictions. The failure of the vertical collaboration resulted in a very segmented network with a stronger transitivity tendency compared to September interactions, and this transitivity tendency created lots of structural holes in the network

(referring to Table 16 in chapter 6). A strong transitivity tendency represents a risk-avoiding attitude of organizations to increase security within the group. It means unless some organizations are recognized by inside group members, they would be open neither to accept nor interact with outside participating organizations. This collaborative structure well reflects (corresponds to) the high tendency of defensive routines and rejection attitudes within cross partnerships in Table 25 in chapter 7. This collaborative structure disconnected between organizational roles and between operational levels, in turn, decreased participating organizations' accessibility to short-cut routes to information and resources at other operational levels.

8.3 How to Help Organizations to Move from Exploitation Routine to Exploration course?

The aforementioned challenges in a coordination are mainly caused by an organizational path dependency to trust and rely on what they already know. If organizations are not familiar with other actors or conditions, they perceive those uncertain or unfamiliar factors to be risks. That's why no information flow within the relief logistics network caused the participating organizations to strongly cling to existing rules, leading to an exploitation strategy in finding partners. In contrast, an exploration coordination strategy, which is considered key for the system to succeed to a changing environment, requires a risk-taking attitude to obtain new types of information, resources, and partner organizations. Very importantly, a coordination should lead participating organizations to change their attitudes (or values) from defensive attitudes toward unfamiliar organizations to proactive attitudes to know and learn about those unfamiliar organizations. This learning process ultimately builds mutual trust among the participating organizations and creates diverse cross-partnerships.

Coordination means more than the place where objective information is exchanged. Coordination should aim at helping participating organizations to build mutual trust effectively with one another.

8.3.1 Information and mode of communication: core energy to build up mutual trust

What communication modes are adopted to deliver information among participating organizations determines a coordination environment. Certain types of communication can(not) create a favorable environment for participating organizations to build mutual trust. Many scholars emphasize developing empathetic dialogue to develop mutual trust (Fligstein & McAdam, 2012; Innes & Booher, 2010). The empathetic dialogue implies face-to-face conversation which delivers not only words but also facial expressions, affection and gestures. These components work together to deliver implied messages in words and information effectively. In this way, the empathetic dialogue generates a mutual learning process which narrows down individual perceptive gaps while building mutual trust by understanding and knowing one another. This learning process helps to change organizational attitudes to see "differences" among each other. When participating organizations start to see organizational differences as "new complementary sources" to complete their understandings about a changing situation and as "synergy" to try new initiatives, this is the very starting point to create new rules adapting to a new environment. Coordination plays the role of a mutual learning process to create collective change for participating organizations to develop and adopt new rules.

8.3.2 Core mechanism to drive exploration approach: Meso-level as a strategic field

The goal of exercising an exploration strategy in coordination is to obtain and integrate new, diverse information into the existing system. This implies the significance of physical accessibility to diverse organizations. If the current coordinating organizations and new types of organizations were not accessible to one another in a practical way, the exploration would not occur. The partnership tendency observed in the October interactions showed that physical proximity and contact among participating organizations at the national level played a critical role in finding new partners. Considering that Liberia had very poor transportation and communication infrastructures, the EOC's physical location served a crucial role in determining the range of the diversity of participating organizations involved in a coordination process.

Referring to Figure 11 in chapter 6, the national level had the highest distributions of participating organizations in October. This indicates that the national level was considered as a strategic level for initiating coordination. However, coordination at the national level created barriers for certain organizations working at different operational levels because of very limited physical accessibilities. These physical barriers disconnected communication across different operational levels and across other organizational roles, which, in turn, caused an exploitation coordination with a strong homophily tendency at the national level. Participating organizations perceived high risk toward different types of organizations working at different operational levels because they were unfamiliar with them. Setting up the wrong strategic field among coordinating organizations degraded the system with the rapid increasing number of affected cases.

In response to a rapidly degrading system performance, the major coordinating organizations set up the EOC at the county level with the same structure of the national EOC,

as shown in the record of November interactions. In Liberia, the county level is physically accessible both from national and community levels even with a poor logistics infrastructure. This high physical accessibility of the county level makes the county level function as a critical meso-level social order in Liberia. When this face-to-face based coordination started to cover a wider range of organizational roles and operational levels, vertical collaboration started to develop. Referring to Table 15 in chapter 5, participating organizations did not have particular (significant) propensity to work with organizations that worked at the same operational levels. In contrast, participating organizations had very strong behavioral propensity to work with organizations who served the same organizational roles. Figure 11 in chapter 6 shows that in November the county level was strengthened with an increasing distribution of participating organization while decreasing organizational distributions at national and community levels. These incorporated results well reflected active vertical coordination between the national EOC and county EOCs. When a new coordination system was introduced at the county level, coordinating organizations located at two different operational levels required extra collaborating efforts to figure out how to build and align their coordination manners across different operational levels.

In addition, Table 19 in chapter 7 highlights the frequency of the increasing face-to-face communication throughout national, county, and community levels across diverse organizations. Table 22 in chapter 7 shows that the cross-partnership performance started to get highly recognized in November. The collaboration performance among cross partnerships became far more responsive with increased collective situational awareness as well as the high performance among the homophily partnerships. Incorporating those results, the exploration strategy was actively implemented in the coordination by including diverse types of organizations across operational levels into a face-to-face coordination both at national and county levels, and their coordination increased collaboration performances of both homophily

and cross partnerships. At the structural network level, this exploration coordination structured a coherently connected structure by merging different clusters (Table 16 in chapter 6). The size of each cluster became not only bigger but also open and merged as the transitivity tendency decreased. These openly merged formats of clusters reflected that different types of organizations started to become open to exchange and accept new ideas and strategies with one another, which is a major feature of the exploration model. The system performance improved and stabilized with a rapid decrease in the number of affected cases.

The county-level EOC established with the staff from national EOC started to serve as the strategic field with the increasing number of participating organizations. The county-level EOC played a role of weak ties in bridging between national and community levels to narrow perceptive gaps among different types of organizations across different operational levels. The coordinating organizations at the national level were closely interacting with coordinating organizations at the county level by telephone to receive new information. Based on the updated information, the coordinating organizations could develop an adaptive policy to meet the current needs in the field in real time. Because the county level EOC coordinators already had shared awareness and views with the national EOC coordinators, even remote electronic communication between national and county EOCs through telephones could keep them in the clear communication. Meanwhile, the coordinators' face-to-face communication with community representatives and field operating organizations at the county EOC developed an adaptive view of the on-going situations in the field. By engaging new information, resources and organizations into the existing coordination system horizontally and vertically, higher situational awareness worked as synergy to develop a new rule to adapt to a new environment, which drove an immediate response of the entire system to the changing environment.

8.4 The Stabilization of a System with New Rules

System evolution requires extra energy and effort to transform the operating manner of a system and to deal with lots of confusion caused by the transforming process. If the environment and system reach a stable point after dynamic changes, the coordinating organizations should strengthen and exploit their current and existing system, keeping the equilibrium (March 1991). When the Ebola operational system reached an optimal performance with steady decreasing number of affected cases in December, the coordinating organizations started to exploit their current strategies, strengthening the county-level coordination system (Figure 11 in chapter 6). The strengthening of county-level coordination occurred when the relief logistics team set up their forward logistics bases (FLBs) that allowed them to manage resource inventories at the county level. After the FLBs were set up, resources could be shared between nearby counties in emergency situations while immediately sending requested resources to communities. While the county EOC played a weak tie role in the information flow, the FLBs at the county level played a weak tie role in the resource flow in the relief logistics network. The strengthening coordination both in information and resources at a county level increased the immediacy of the system adaptations.

The December record of interactions showed that coordination achieved both horizontal and vertical collaboration systems, showing moderate levels of homophily partnerships within the same operational level and within the same organizational roles in Table 15 in chapter 5. Here, it is very important to understand how to interpret the meanings of these statistical results reflecting the contextual changes. A strong homophily propensity of organizational partnerships at the same operational level in October indicates strong collaboration exclusively at the national level. In contrast, the decreasing homophily propensity of organizational partnerships at the same operational level in December indicates that

organizations coordinate both within each national and county levels and between national and county levels. Unlike October, the strong homophily propensity of organizational partnerships within the same organizational roles in December implies coordinating organizations and relief logistics working at national and county levels closely worked together after they had county-level EOCs and FLBs.

The horizonal and vertical partnerships are assumed to have been strengthened by the prevailing pattern of the face-to-face coordination across the types of participating organizations and operational levels (referring to Table 20 in chapter 7). This research argues that this horizontal and vertical partnerships were driven by an exploitation strategy as a continuation of the November coordination pattern, rather than by an exploration strategy to try a new coordination manner. The number of incidents of the face-to-face coordination among cross partnerships increased in December (175 times) compared to November (155 times) (Table 22 and 23 in chapter 7), but the December performance of cross partnerships were recognized as high as the performance in November (Table 25 and 26 in chapter 7). It indicates that the participating organizations did not make extra efforts to improve the performance. Rather, they focused on maintaining the coordination routine established in November, because this routine already stabilized the system. Another interesting point is that the recognition of the coordination relying on long-term regular interactions within homophily partnerships decreased in December (Table 23 in chapter 7). This phenomenon signifies that the participating organizations actively learnt on-going Ebola situations through the established coordination channel optimizing the Ebola operation, rather than working through long-term regular operational routine. In contrast, the steady homophily effect of the same original locations in finding partners over time (Table 15 in chapter 5) signifies very embedded effect of informal institutions in organizational behaviors. Those informal institutions including

cultures and languages serve as a critical baseline of organizational values and choices, which remains hardly changed through external interventions.

As the system was stabilized with the steadily decreasing number of affected cases, many participating organizations left the network. Nevertheless, the network steadily maintained high efficiency by being inherently connected with bigger open communities (Table 16 in chapter 6). That the network structure entered into a quasi-equilibrium status signifies that organizations which successfully adapted to an environmental change remained in the network to serve. In contrast, those organizations that failed to adapt to the changing environment (or failed to contribute to the system evolution) left the system.

8.5 Contributions and Limitations

Using an abductive approach, this research shows how each different theory complements a framework to understand this dynamic complex situation. By decomposing a complex phenomenon into different levels of analyses, this research showed the evolution process of each level not only independently in parallel but also interactively. Through this analytical process, this research made theoretical, methodological, and practical contributions to the existing research and practical approaches in the field of disaster management.

8.5.1 Theoretical contribution

First, this research highlighted the changing condition of organizational attributes. Reflecting the fast-changing characteristics of a disaster response environment and context, this research emphasized that the organizational attributes are redefined after joining a relief operation. This research tried to expand the understanding of organizational existing and new

attributes as core informal rules of organizational behaviors. Furthermore, by integrating the organizational attributes with an organizational homophily propensity in collaboration, this research showed dynamic perspectives of an organizational decision-making process. The empirical examination in the research was used to show how the effectiveness of existing and new organizational attributes affected the organizational behavioral evolution.

Second, this research applied an evolutionary network analysis to investigate the series of the structural changes in the context of organizational collaboration in response to a disaster. This research illustrated in certain conditions how a relief logistic network forms in different stages of the network evolution. This research connected the individual behavioral rules with the network forms. Supported by theoretical and contextual understandings, this connection explained how those individual actions could draw a certain structure for a collective network. In other words, the implications of network forms were explained with the coordination status embedded in organizational behavioral patterns. Without this connection, the coordination strategies to develop efficient collaboration would not be clear and practical enough because the network structure itself does not explain why a certain inefficient collaboration structure was created. This research explored this interactive mechanism in an empirical way.

Furthermore, this research explored particular communication conditions to improve the collaboration performance among participating organizations. Even though there were many theoretical discussions of the importance of communication modes in coordination, very few studies showed the effectiveness of different communication modes. This research integrated theoretical discussions between particular communication modes and the role of meso-level organizations in coordination. This integrated approach clarified more specific conditions to create an effective communication concerning where to meet, how to communicate, and in what conditions multiple communication modes can complement one another to improve collaboration performance.

8.5.2 Methodology contribution

This research showed the significance of a mixed-method approach applying different data sources and analysis methods to complement each analysis result, using different data sources. This complementary understanding developed through the integration of different results minimizes interpretation biases caused by limited understanding of a context, while expanding the horizon of the view toward a certain phenomenon. Statistics results show causal relationships among factors. However, the results could not explain the mechanism of why a certain factor was introduced, how those certain causal factors worked to produce a certain result, and what was the meaning of those relations reflected in a certain context. Even though the causal relations are generally found in different contexts, the mechanism and interpretation could be different from one another. The network analysis results also require the understanding of a mechanism and process of why and how a certain interdependent relationship is established. Those outcome and process are affected by contextual characteristics where the network was formed, which is important features to understand (Kenis & Provan, 2009; Turrini, Cristofoli, Frosini, & Nasi, 2010). The qualitative analysis using semi-structured interview data and official documents provide contextual information to understand the mechanism embedded in statistical and network analysis results.

As each analysis method fills the gaps that other analysis methods have, this research presented the strength of mixed-method analysis to increase the validity of interpretation by providing multi-dimensional perspectives of the Ebola operation system. The archive documents at the ReliefWeb provided good information of how international and national governmental organizations collaborated in the relief logistics network. Since those official documents were mostly developed by major international and national agencies, those documents were somewhat biased with narrow views reflecting their perspectives only. And

those official documents written based on facts (what they have done things) could not provide information of a detail process of the mechanism changes (how they have done) in the system. Particularly, those documents mentioned how diverse organizations worked at the county level in detail only after the international and national coordinating organizations set the county EOCs. It means that those documents missed all critical information about county and community levels in September and October where the number of affected cases far increased. Semi-structured interview data collected through Liberian residents who participated in the Ebola operation as members of participating organizations tremendously filled critical perceptive gaps. Those interviewees provided information not as organizational representatives but also as residents living at county or community levels. This interview data greatly strengthened the interpretations of statistical and network analysis results, which built a comprehensive and precise operational picture according to timelines. This research contributes to widening a methodological approach in the field of a relief logistics network.

This research also contributed to a qualitative analysis approach with developing a coding process and new measurements of a concept. To capture a time-series change of organizational performances as precise as possible, this research suggested how to minimize the coding biases in a qualitative study. This research drew the significances in coordination changes from co-occurrence tables which reflected the frequency of interviewees' answers. If an interviewee overly emphasized a certain phenomenon, and a researcher counted the mere number of words or concepts mentioned by interviewees, the implication drawn from the co-occurrence table could be biased caused by an over-weighted issue. This research presented how to code interview data based on concepts. With a specific illustration of the coding process, this research can help future researchers avoid coding bias in a qualitative analysis using semi-structured interview data.

8.5.3 Practical implications

The flexibility of a relief logistics network does not come from advanced techniques; rather, the flexibility of a relief logistics network comes from organizational mutual trust that increases organizational adaptations to one another within a changing environment. The relief logistics network represents the flow, direction, and development of mutual trust. This significance indicates that the policy should focus on how to build mutual trust effectively among participating organizations. As a way to build mutual trust, this research provided a very practical coordination framework to illustrate what/how coordinating organizations should prepare coordination strategies at different levels of collaboration. It provided a visible picture both in micro and macro perspectives as a result of coordination using particular communication modes. This picture is persuasive for coordinating organizations (and any participating organizations) to see the significance of choosing effective coordination modes related to a collective performance.

Concerning policy implications, behavioral change is much faster than moving resources or building new infrastructure. Particularly in degraded conditions of transportation and information infrastructure, resource transmissions across different regions take a long time. During the 2014 Ebola crisis, ETUs and FLBs were obviously critical facilities in treating and supporting affected cases with medical resources. Even though the plans to set up those facilities were developed in September, those facilities started to function only after the situation was under control with a decreasing number of affected cases. The key policy should be changing people's behaviors rather than fully relying on external resources in an epidemic crisis. Particularly, donors are very fluid with short-term commitment, whereas the community is proactive for long-term commitment. Coordinating organizations need to appreciate and

recognize the capacity of community. In a long-extended crisis, coordinating organizations should integrate community organizations effectively into a coordinating system.

8.5.4 Future research

This exploratory study drew meaningful implications that can be applicable to any type of situation involving organizational collaboration. Yet, this research is very contextualized into an under-resourced condition in response to an unprecedented crisis. In response to a familiar or seasonal disaster in a well-resourced condition, other factors could be more important to increase the system performance. Also, this research developed by an abductive approach drew out assumptions illustrating a phenomenon in terms of "may be". To generalize the framework, the research findings need to be tested and strengthened through other empirical tests applied to different situations.

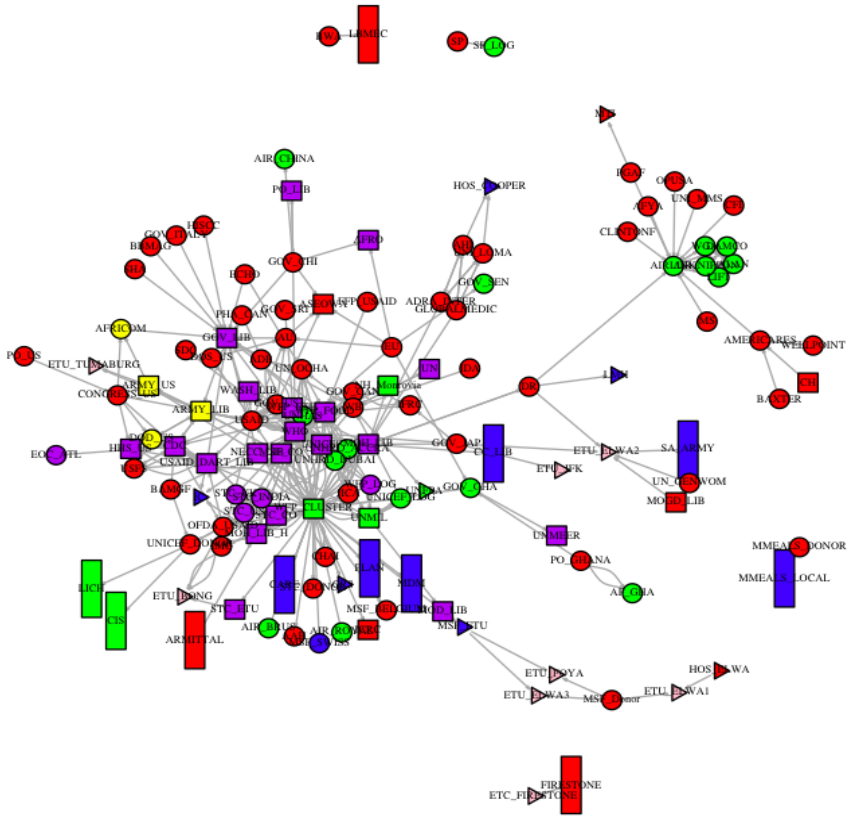
This research missed a connection between an inventory change and system performance due to limited inventory data. If these two perspectives are connected, it would provide a clearer picture by showing how much those resources could contribute to practically improving the entire system performance. By combining these quantitative data with the current findings, future research could be developed as a system dynamics model capturing both individual and interactive impacts among coordination, individual and collective organizational behavior on the system's performance simultaneously.

Table 27 System Evolution Process in the 2014 Ebola Relief Logistics Network

	(September) System Emergence	(October) System Degradation	(November) System Evolution	(December) System Stabilization
Coordination Mechanism	• Establishment of face-to-face coordination at a national level	• Frequent face-to-face coordination at a national EOC • Low recognition of face-to-face coordination within cross partnerships • High recognition of no communication within cross partnerships	• Frequent face-to-face coordination at a national EOC • Establishment of face-to-face coordination at a county level • Vertical coordination between national and county EOCs • Increasing recognition of face-to-face coordination within both homophily and cross partnerships • Decreasing recognition of no communication within cross partnerships	• Frequent face-to-face coordination at a national EOC • New establishment of face-to-face coordination at a county level • Close coordination between national and county EOCs • More recognition of face-to-face communication within the cross partnerships
Individual Organizations' Behavioral Tendency	• Relied on existing organizational rules : Strong homophily within the same organizational tiers and original locations	• Highly relied on physical accessibility in the field : Strong homophily within the same operational level • Moderate homophily within the same organizational tiers, original locations, and organizational roles	• Highly relied on an organizational role, whereas no significant effect from the operational level • Moderate effects of existing attributes	• Relied on an organizational role with less significance of physical accessibility • Moderate effects of existing attributes
Collaborative Network Structure	• Relatively fragmented and inefficient structure	• The most fragmented and inefficient structure with many separated clusters.	• Coherently connected structure with the highest	• Coherently connected structure as a whole with

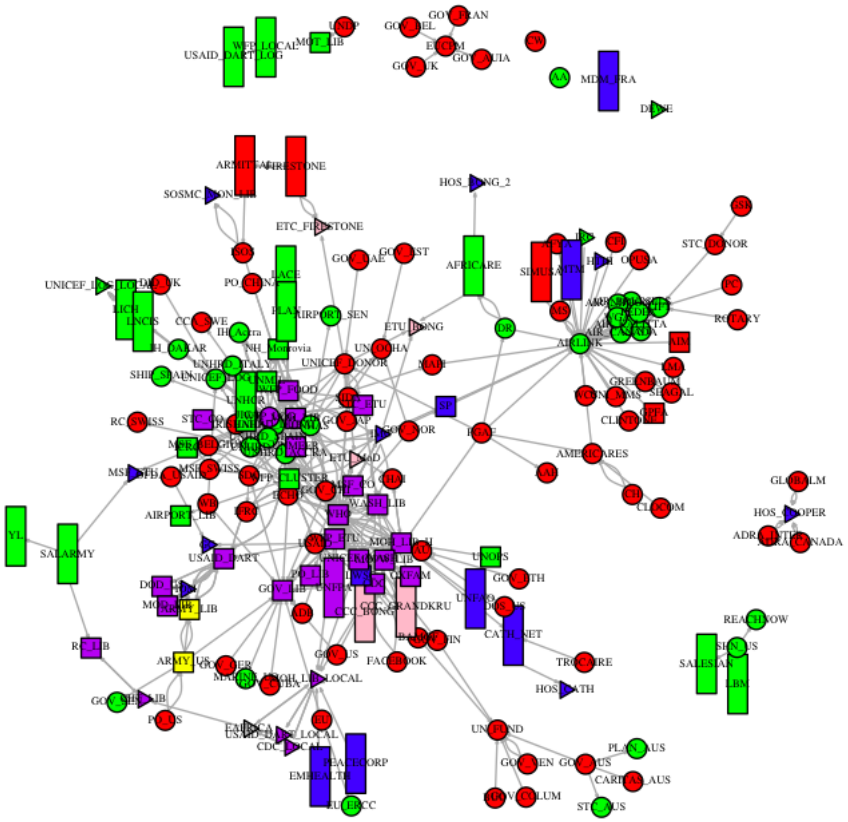
	(high transitivity and lower reachability)	Individual has the lowest accessibility to short-cut routes	accessibility to short-cut routes • Longer geodesic length and less reachable form	high accessibility to short-cut routes • Shorter geodesic length and higher reachability
Collaboration Performance	N/A	• Relatively high recognition of immediate response and collective situational awareness within homophily partnerships • High recognition of defensive routine and rejective attitude within cross partnerships	• Far increasing recognition of immediate response and collective situational awareness within both homophily and cross partnerships • Decreasing recognition of defensive routine and rejective attitude within cross partnerships	• Steady recognition of immediate response and collective situational awareness both within homophily and cross partnerships • Increasing recognition of information exchange within cross partnerships
Coordination Strategy	N/A	Exploitation	Exploration	Exploitation
System Performance	Steady increase of the number of affected cases	Rapid increase of the number of affected cases	Rapid decrease of the number of affected cases	Steady decrease of the number of affected cases

Appendix A Features of the Relief Logistics Network in Response to the 2014 Ebola Crisis in Liberia



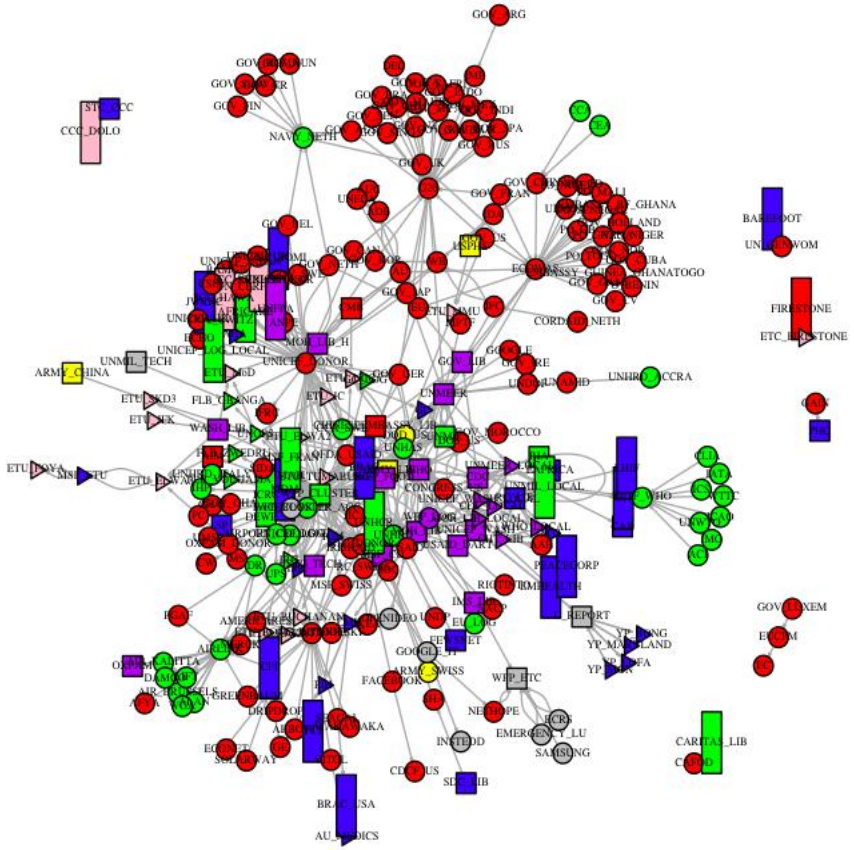
Org. Role	Color	Op. Level	Shape
Donor	Red	International	Circle
Logistics service	Green		
Army	Yellow	National	Square
Coordinator	Purple		
Field operator	Blue	County	Triangle
ETUs	Pink		
Communication	Grey	Community	Rectangle

Figure 13 September Network Feature



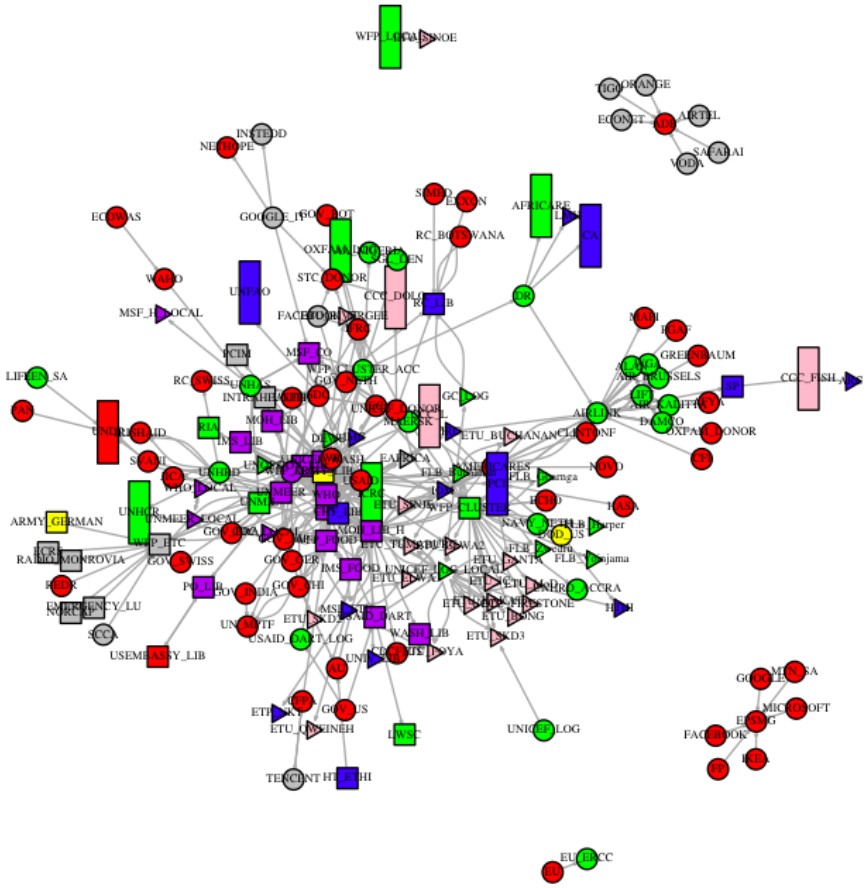
Org. Role	Color	Op. Level	Shape
Donor	Red	International	Circle
Logistics service	Green		
Army	Yellow	National	Square
Coordinator	Purple		
Field operator	Blue	County	Triangle
ETUs	Pink		
Communication	Grey	Community	Rectangle

Figure 14 October Network Feature



Org. Role	Color	Op. Level	Shape
Donor	Red	International	Circle
Logistics service	Green		
Army	Yellow	National	Square
Coordinator	Purple		
Field operator	Blue	County	Triangle
ETUs	Pink		
Communication	Grey	Community	Rectangle

Figure 15 November Network Feature



Org. Role	Color	Op. Level	Shape
Donor	Red	International	Circle
Logistics service	Green		
Army	Yellow	National	Square
Coordinator	Purple		
Field operator	Blue	County	Triangle
ETUs	Pink		
Communication	Grey	Community	Rectangle

Figure 16 December Network Feature

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