Impacts of Government Reorganization on Inter-Organizational Networks: Analysis of South Korea's Disaster Response Networks

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To those beautiful young souls we lost on April 16, 2014.

슬픔을 이불로 덮고 잠이 들은 작은 꿈들아 이젠 따뜻하길*

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Governments face challenges dealing with uncertainty and complexity under dynamic conditions of disaster. Since the disaster management system of a government involves multiple actors that are interconnected, it is critical that they maintain their respective functions despite rapidly changing environments. The purpose of this research is to seek how diverse government organizations could perform better amid disaster by developing ties with one another. The government reorganization is assumed to have influence over relationships among multiple organizations in the disaster management system. Thus, this research intends to answer the question: How does government reorganization affect the government's inter-organizational networks and network effectiveness in the dynamics of disaster?

Although the number of research studies on government reorganization and inter-organizational networks has accumulated, efforts to associate these two topics have been scarce. Furthermore, much of the focus was on outcomes of reorganization in terms of measurable indicators such as expenditure and employment. This research proposes to examine the effects of government reorganization with respect to inter-organizational networks. Analyzing the functional arrangements before and after reorganization will help to understand how structural changes affect changes in networks performance.

The method of network analysis is employed complemented by semi-structured interviews with public officials within the Ministry of Interior and Safety. The data of two earthquakes in Korea, Gyeongju earthquake in 2016 and Pohang earthquake in 2017, are utilized and compared.

The findings indicate that government reorganization does have an impact on inter-organizational networks. Noticeably, the organizations tend to be more centralized toward the organization which consolidated similar functions. In contrast, communicative power is relatively disseminated in the network where a key organization integrated dissimilar functions. The results of the interviews indicate that actual power and resources over other organizations, particularly over local government, is important to facilitate coordination in response to disaster. The implications are that to maintain stability and flexibility in disasters, it is critical to consider the structural arrangements of multiple organizations in terms of their functions.

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List of Acronyms

Acronym	Organization
BC	Busan City
CDMHQ	Central Disaster Management Headquarter
CDSCHQ	Central Disaster and Safety Countermeasures Headquarter
CERCG	Central Emergency Rescue Control Group
CHA	Cultural Heritage Administration
CRC	Central Rescue Center
CWC	Changwon City
DC	Daegu City
GC	Gumi City
GJC	Gyeongju City
HG	Haeundae Gu
KCC	Korea Communications Commission
KCG	Korea Coast Guard
KDCA	Korea Disease Control and Prevention Agency
KFS	Korea Forest Service
KMA	Korea Meteorological Administration
MAFRA	Ministry of Agriculture, Food and Rural Affairs
MCST	Ministry of Culture, Sports and Tourism
MGEF	Ministry of Gender Equality and Family
MIS	Ministry of the Interior and Safety
MND	Ministry of National Defense

MOE	Ministry of Education
MOEF	Ministry of Economy and Finance
MOEL	Ministry of Employment and Labor
MOEN	Ministry of Environment
MOHW	Ministry of Health and Welfare
MOI	Ministry of Interior
MOJ	Ministry of Justice
MOF	Ministry of Oceans and Fisheries
MOLIT	Ministry of Land, Infrastructure and Transport
MOTIE	Ministry of Trade, Industry and Energy
MPSS	Ministry of Public Safety and Security
MSIF	Ministry of Science, ICT, and Future Planning
MSICT	Ministry of Science and ICT
MSPA	Ministry of Security and Public Administration
NEMA	National Emergency Management Agency
NFA	National Fire Agency
NPA	National Policy Agency
NGP	North Gyeongsang Province
NSSC	Nuclear Safety and Security Commission
PC	Pohang City
SGP	South Gyeongsang Province
UC	Ulsan City
UJC	Ulju County

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Most of all, I give thanks to God who "*showed his great love for us by sending Christ to die for us while we were still sinners."* (Romans 5:8)

1.0 Introduction

The purpose of this research is to achieve implications on how various government organizations could improve working with each other amid extreme conditions of disaster. The emphasis is on seeking the way government organizations collaborate as identified from the ties they develop in response to disaster. The government reorganization is considered as an important factor that is assumed to have an impact on the relationship among organizations, or inter-organizational networks. Uncertainty and complexity of disaster intensifies the dynamics of environments and urges the actors within the disaster management system to explore connections so that they can maintain their functions despite intractable agitations. In this regard, inter-organizational networks in response to two earthquake cases of Korea - 2016 Gyeongju earthquake and 2017 Pohang earthquake - will be analyzed and compared to gain understanding about how changes in government organizations affect other related organizations, which in turn is thought to influence the system as a whole.

1.1 Background

Reorganization of government is often sought as a breakthrough when a government is confronted with multiple challenges. Sometimes it is initiated to enhance the effectiveness of bureaucracy; sometimes to secure the legitimacy of a new administration; and other times as a symbolic use for politics (Edelman, 1985). Whatever the stated goals are, outcomes of government reorganization account for its actual significance. Several studies investigate the impact of

government reorganization but much of the focus was on measurable outcomes, such as expenditure and employment etc. (Adamski et al., 2006; Andrews and Boyne, 2012; Brademas, 1978; Meier, 1980; Park et al. 박치성 외, 2011). However, we should also note other aspects to the consequences of government reorganization particularly when it is associated with many other organizations. This research examines the effects of government reorganization, as revealed in inter-organizational networks. In this section, the goals and outcomes of government reorganization in general will be addressed, followed by government reorganization in the specific context of Korea.

1.1.1 Goals and Outcomes of Government Reorganization

Government reorganizations have been accomplished in different forms considering specific goals. One goal was to enhance bureaucratic efficiency or presidential control. Such a goal was thought to be achieved by centralizing control to the executive branch (Thomas, 1993). Some argued that the president was the "focal point" of administrative management that has the authority to overcome the interests of agencies and the Congress (Emmerich, 1971). Yet, contrary to the belief that centralization to the executive branch bolsters efficiency and control, the cases examined demonstrated somewhat different aspects (Thomas, 1993). For example, in 1953, the United States Department of Health, Education, and Welfare was established, consolidating diverse agencies, that maintained their respective cultures and congressional supporters without significant changes (Wilson, 1989).[1] In this case, the functions of each component were largely independent, although they were structurally consolidated. Wilson (1989) argued that the core

[1] In 1979, the Department of Education departed from the Department of Health Education, and Welfare and so HEW was renamed to the Department of Health and Human Services.

tasks of the bureau need to be redefined to avoid disturbance owing to the merger of diverse agencies. In other words, if the core tasks of certain units within a department are considered unimportant to the rest of the department, they would likely be disregarded by the top executives (Simon et al., 1950).

Some government reorganizations had similar goals but were realized in somewhat different forms. That is, an independent organization was incorporated into an executive branch to expand the control over a governmental function. Yet the incorporated organizations do not always align to the common mission of the department (Emmerich, 1971; Thomas, 1993). Furthermore, while some contend incorporating smaller units in large departments inhibits capture (Fesler, 1974), it is also likely that interest groups seek advantage by placing certain functions within a large department (Moe, 1989). For instance, in the case of transferring the Bureau of Employment Security from the Federal Security Agency to the Department of Labor, the interest groups gained greater influence from the reorganization as opposed to their assumption (Rourke, 1957). In contrast, it was noted that if the Corps of Engineers were to be relocated into the Department of Interior, the environmental missions may be absorbed by the Bureau of Reclamation (Rourke, 1957). Thus, integrating an independent organization into the executive branch may or may not avoid capture, which makes it difficult to ensure that the very incorporation strengthens executive control over related government function.

At the opposite end, there is a goal of achieving independence from presidential control through reorganization (Thomas, 1993). This is actualized by creating an independent agency or commission. Unlike an organization that is under the direct authority of the president, this kind of reorganization may be more complicated since it engages independent agencies, multi-headed boards, and commissions potentially having to consider a wide variety of interests. In addition, it

is not always clear whether creating independent agencies warrants independence of the organization. On the contrary, even without establishing an independent agency, some executive departments incorporated agencies while maintaining their own independent systems (Seidman and Gilmour, 1986). An independent agency may gain funding certainty and prevent extra layers of decision making. For example, the Federal Aviation Administration might have greater funding opportunities by avoiding the departmental budgetary review before being reviewed by the Office of Management and Budget if it becomes independent (Wise, 1989). Also, fewer layers, meaning less complexity, might enhance the possibility to have important issues raised by the agency. However, staying with the executive branch, rather than becoming an independent agency, might grant them greater political power. For example, the FAA could better coordinate with the national transportation policies by avoiding more specific issues (Wise, 1989).

As discussed, it is not always likely that the intended goals are achieved by reorganization implying a gap between intended outcomes of government reorganization and actual outcomes. Thomas (1993) argued that we still lack understanding of the effects of reorganization and evidence is scant. However, the studies seeking the effects of government reorganization have continued to report mixed assessments. Some studies recognized insufficiency of reorganizations with respect to performance. Birkland (2004) argued that while focusing event – September 11 – led to policy changes and created the Department of Human Security (DHS), the mission and function of the department were unclear. Consequently, Hurricane Katrina disclosed the problems that emanated from reorganization based on insufficient thought on how change of policy instrument might affect policy outcomes. Reese (2004), based on the research of metropolitan reorganization, acknowledged the inherently dynamic characteristics of structural change. She noted that "*how governments are designed on paper is often not how they operate in practice*"

(Reese, 2004). Conley (2006) analyzed the organizational reform - the creation of DHS - after 9/11 in the Bush administration and argued that such a reform was not adequate for major incidents. In fact, as seen in the case of hurricane Katrina, federal, state, and local officials failed to communicate with one another effectively (Conley, 2006). Others found impacts of reorganization on performance or policy outcomes. In terms of economic performance, Li and colleagues (2016) found that diminishing government layers increased revenue and intergovernmental transfers for the county governments, but it became difficult for upper-level governments to coordinate and monitor local governments. Hong and Park (2019) documented significant impact of administrative reorganization on relative salience of policy issues. At the same time, they argued that such an increase of salience cannot be asserted as positive or negative signs of policy outcomes.

Despite ongoing research trying to uncover the consequences of government reorganization, it is difficult to determine the agreed-upon effects of government reorganization. In fact, we need to be cautious not to conclude that a certain form of reorganization is more effective in achieving certain goals. This corresponds to Hult's (1987) proposition that consequences of reorganization depend on a variety of factors - technical uncertainty, resources scarcity, and changes in issue salience. To better understand the specific role of reorganization in Korea, the context of the Korean government is introduced.

1.1.2 Reorganization in the Context of Korea

The Korean government, marked by strong presidential authority, is more centralized in terms of exerting power over government arrangements. Historically, government reorganization was sought in every new administration whether it was stated to be for the sake of efficiency, effectiveness, or political benefits. Despite the varying rationales for such organizational reforms,

many presidents shifted from their initial frameworks during their administrations, proving their inattentiveness to other factors that were insufficiently considered. For example, President Youngsam Kim (1993 ~ 1998) originally stressed integration and downsizing of government organizations under the slogan of New Public Management. However, during the second half of his term in office, he established new organizations diverting from his initial plans to reduce the government size and enhance efficiency (Park J.H., 2016). During the early phase of the Youngsam Kim Administration, the Ministry of Culture and Ministry of Sports were integrated into the Ministry of Culture and Sports; the Ministry of Commerce and Industry and the Ministry of Energy were consolidated into the Ministry of Commerce, Industry and Energy. After the mid-phase of the administration, new organizations were generated including the Small and Medium Business Administration and the level of the existing organization, the Korea Coast Guard, was elevated.

In some cases, gaps were observed between what was explicitly iterated versus what was actually employed. Despite President Taewoo Roh's (1988 ~ 1993) pursuit of small government, the organization and personnel expanded during his presidency. Amid explosive social participation calling for democratic government at the turn of 1990s, the demand for administrative actions increased immensely. Such a context necessitated the government to respond efficiently, yet the goal of creating efficient government by downsizing the organizations failed.

Government reorganization in response to external shocks was identified in several administrations. To overcome the IMF crisis in 1997 due to severe foreign exchange shortage, President Daejung Kim (1998 ~ 2003) split the Board of Finance and Economy into three organizations: the Ministry of Finance and Economy, Strategy and Budget Committee, and Financial Supervisory Commission. During President Moohyun Roh's terms in office (2003 ~

2008), the Daegu subway fire in 2003 stimulated the government to establish the National Emergency Management Agency. In 2014, the Geunhye Park (2013 ~ 2017) Administration established the Ministry of Public Safety and Security in response to criticism from the public regarding the government's inability to respond to the *Sewol* ferry disaster.

Taking office after the former president Geunhye Park's impeachment, President Jaein Moon (2017 ~ 2022) did not form a presidential transition commission but rather designed and approved a reorganization plan based on what had been stated as an election pledge. A few of the major changes included establishment of Ministry of SMEs and Startups, launch of Science, Technology, and Innovation Office (vice-ministerial level) under the Ministry of Science and ICT, separation of National Fire Agency and Korea Coast Guard out from Ministry of Public Safety and Security, reorganization of Ministry of Interior to Ministry of the Interior and Safety by incorporating Ministry of Public Safety and Security.

With respect to institutions, Korean presidents hold the authority to propose legislation. Thus, presidential candidates competitively redesign new administrative structures as a part of their election pledges to win votes. When elected, the presidential transition committee takes the lead and arranges the new organizations, which in turn are approved through a series of political negotiations with the Assembly. Consequently, the new administrative structure is applied to the Government Organization Act and then is declared to the public. Thus, many presidents have accomplished multiple restructuring efforts within their five-year terms of presidency. Although Korea maintained a divided government from 1988 through 2000, since 2004 through 2020 - except for 2016 (20th general election) - it retained a unified government, which means that a majority of the Assembly members were from the same political party as the executive.

In comparing how different organizational structures impact performance in disaster management, alternatives of reorganization need to be classified considering a number of distinct characteristics of government reorganization in Korea. From Thomas's (1993) categorization of the alternatives of reorganization, three relatively centralized alternatives were considered: i) centralized hierarchical relationships within executive branch ii) independent organization incorporated into executive branch iii) independent agency or commission. This classification is adapted based on some distinguishable characteristics of Korea associated with government reorganization.

First, creation, restructuring, and abolition of organizations have been executed with the president at the focal point. Presidents, having authority to propose legislation, can structure government organization in ways they deem could achieve their goals. Particularly in the early stages of a new administration, the president's political goals are reflected in the designs of the new government in efforts to differentiate it from the former administration. Therefore, in Korea, the government reorganizations are largely impacted by the president and ruling party's political and policy orientation.

Second, reorganization has been used to stress what the focus of each administration is as reflected in the frequent changes in names of the government agencies. Thus, it is possible to infer from the names of new organizations what the government is trying to achieve or highlight. One example is when the former President Geunhye Park, in 2013, changed the name of the 'Ministry of the Interior and Safety' into the 'Ministry of Security and Public Administration' to prioritize safety over administration. However, such naming does not guarantee its intended effects. Rather, it implies the symbolic function of reorganization imposed by the names of organizations.

Incorporating these two distinct features of reorganization by the Korean government, adjustments are made to Thomas' (1993) classification on alternatives of reorganization. Since the scope of the research is limited to agencies and commissions under the executive branch, it cannot be fully independent from presidential control. Rather than labeling it independent based on the degree of presidential control, it is more relevant to examine the configurations of functions. By investigating the changes in functional arrangements entailed in reorganizations, we gain understanding about how the structural changes are linked with changes in networks.

1.2 Significance of Research

Although studies trying to figure out the impacts of reorganization have accumulated, most of the attention was directly on measurable outcomes such as expenditure, employment, and economic performance etc. Yet, outcomes of reorganization are determined by diverse factors (Hult, 1987) implying that it would be inadequate to infer relationships with limited indicators of outcomes. Particularly in extreme conditions of disasters, during which various actors are engaged, dynamic characteristics of structural change are compounded by interdependent relationships among the actors. Rather than directly linking government reorganization to certain outcomes, this study investigates the formation of networks among government organizations in disaster management.

The idea of considering diverse factors conforms to the institutional approach of government reorganization. As March and Olsen (1983) conceptualized, organizational change is like a garbage can, where problems, solutions, decision makers, and choice opportunities come together independently and yield unplanned outcomes. In organizational changes, this can be

thought of as changes being triggered when the multiple factors meet concurrently. Consequently, it is difficult to predict as to when the change will happen and exactly under what circumstances. In addition, whereas the ecological approach views organizations as dependent on the environment, the institutional approach considers organizations to create collective values all the while granting their relationships with the environment (Peters, 1992). Thus, in this research reorganization will be probed in relations to other organizations and the environments that surround them.

As discussed, governmental reorganization in the context of Korea is distinctive in that reorganizations occur frequently; and quite often are used as symbols for political purposes. Rather than viewing reorganization as a structural change which that merely serves as a framework for how governance occurs (Reese, 2004), this study begins from the underlying assumption that government reorganization means more than just a background set. That is, government reorganization is considered to have a critical impact on interaction among the actors within the system. Methodologically, network analysis is employed. Unlike other methods seeking linear relationships between government reorganization and dependent variables, the network approach acknowledges contexts, activities, and outcomes (Diani and McAdam, 2003). By exploring the networks and the evolution of networks over time, the empirical patterns reflecting the real world could be identified which provide implications about ways to strengthen the system.

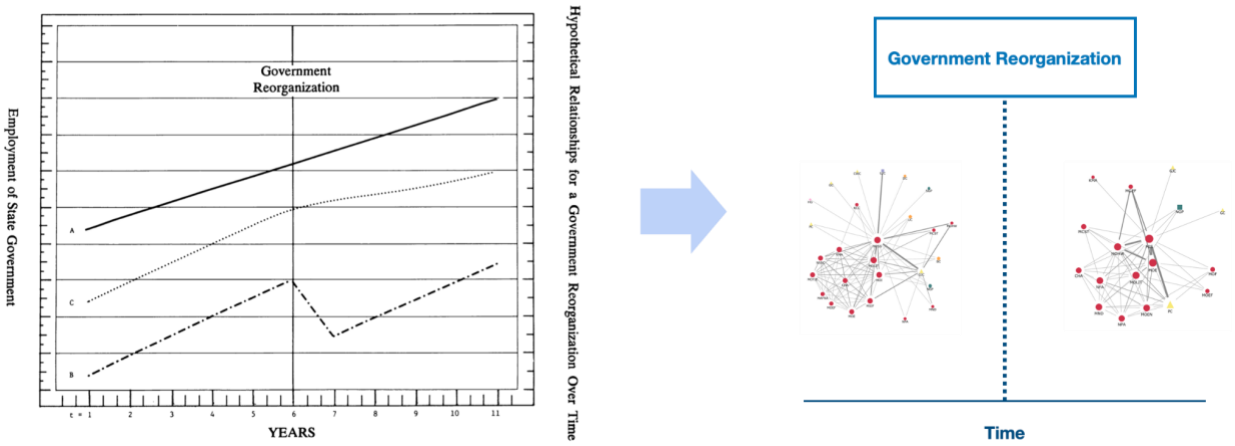


Figure 1. Significance of the Research

Source(Left): Hypothetical Relationships for a Government Reorganization Over Time. Adapted from "Executive reorganization of government: Impact on employment and expenditures" by K. Meier, 1980, *American Journal of Political Science*, p.403.

1.3 Research Questions

Government organizations are not merely participants of the larger policy network, but form networks that create multiple levels of strategic action fields (Fligstein and McAdam, 2012). To maintain stability in dynamic conditions, organizations (otherwise called agents, actors) or groups of organizations (networks) seek to adapt to the environment by interacting with others. Both stability and flexibility are necessary to account for network effectiveness. Based on such notions, the following research questions are posed.

"How does government reorganization affect the government's inter-organizational networks and network effectiveness in the dynamic context of disaster?"

Question 1: How does reorganization affect interorganizational networks?

Question 1-1: What are the similarities and differences of the whole network before and after reorganization?

Question 1-2: Who are the major actors within the network before and after reorganization?

Question 1-3: How do the sub-network level communities change after reorganization?

Question 2: In what ways does government reorganization influence network effectiveness in disaster management?

Question 2-1: How does government reorganization impact the effectiveness of the network?

Question 2-2: What are the shared understandings about inter-organizational networks of disaster management system under dynamic environments?

Question 3: How does government reorganization impact the evolution of inter-organizational networks in response to disaster?

The questions seek to identify the relation between government's structural changes and inter-organizational networks focusing on disaster management. Although there is extensive literature on government reorganizations and interorganizational networks, research associating those two topics is scarce. Indeed, the government's structural changes alone cannot fully account for interorganizational dynamics. Still, it is useful to investigate the networks of organizations and how they unfold over time.

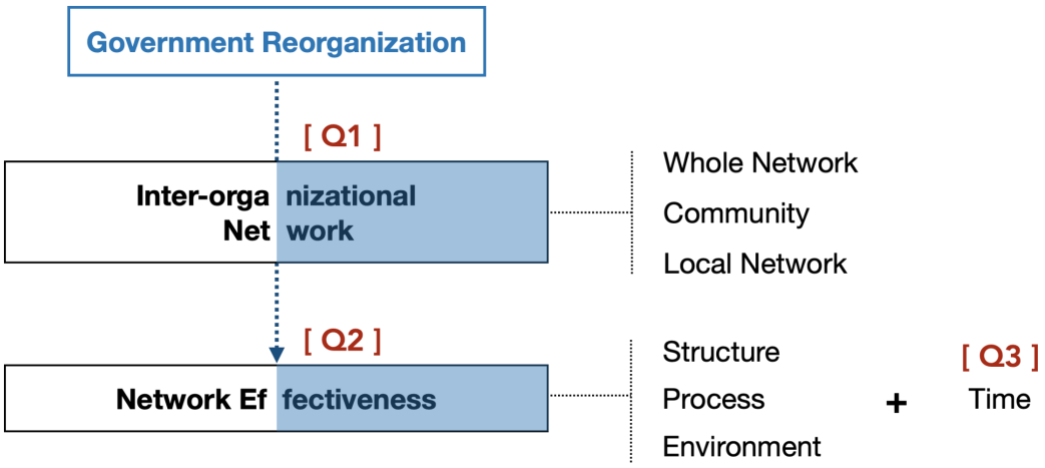


Figure 2. Conceptual Framework

2.0 Literature and Theoretical Framework

Since a government is composed of various agencies and organizations, it inherently involves relationships among those actors. This could be demonstrated as a network. And thus, in this chapter, the literature on inter-organizational networks is discussed. First, the usefulness of the network approach is addressed, followed by a policy network and the role of the government within the policy network. Then, different approaches to, and factors affecting network effectiveness are discussed. Finally, the theoretical framework based on complex adaptive system and theory of fields is introduced.

2.1 Usefulness of Network Perspective

The tendency toward highlighting the importance of network has been an ongoing trend over the past few decades (O'Toole, 1993; Huxham, 2003; Rethemeyer and Hatmaker, 2008; Chen, 2008; McGuire and Silvia, 2009; Meier and O'Toole, 2003; Thomson and Perry, 2006; Agranoff, 2007; Provan and Kenis, 2008; Kapucu et al., 2010; Guo and Kapucu, 2015). Although there is no set agreement on the conceptualization of the terminology (Huxham, 2003), the network perspective provides profound descriptive ability and methodological rigor in interorganizational phenomena (Fountain, 1994). Generally, the network approach complements other approaches by helping researchers to recognize movement elements from contexts, activities, and outcomes (Diani and McAdam, 2003). An increasing number of scholars are applying the network approach

and concepts, viewing them as representing structures of relational patterns underlying diverse social units (Scott, 2011).

The study of networks is closely related to interorganizational theory. Interorganizational theory deems organizations to be placed within environments, which set parameters and determine criteria for effectiveness (Hage and Aiken, 1969; Lawrence and Lorsch, 1967). By utilizing an interorganizational perspective, policymakers can understand what they can do, what is possible, and what is not possible (Wise, 1990). However, merely developing a network or participating in a network does not guarantee a better performance. In addition, since the network settings tend to be uncertain and complex, cooperation and coordination become difficult tasks and network action needs to be induced (O'Toole, 1993).

To elicit effective outcomes from networks, clear goals and focused actions are necessary. Just like managing individual organizations, networks of organizations need direction as well. Network management is defined as "*the **strategic activity** meant to influence **the interaction of the nodes (actors)***" (McGuire and Bevir, 2011). In public management, network encompasses diverse actors - governmental and non-governmental - that are linked through involvements in public policymaking and/or administrative structure (McGuire and Bevir, 2011). Thus, the first step toward strategic management of networks is analyzing the interactions among the actors and assessing the outcomes of networks.

2.2 Policy Network

While government organizations are inherently rigid with their hierarchical structures, their involvement and roles within a policy network opens the possibility for gaining flexibility with

respect to interactions with other organizations both public and private. A policy network is defined as relationships formed by the elements of the civil society and a government to establish policies (Montpetit, 2002). Those who participate in the policy network interact with one another for the commonly agreed upon purposes and develop a structure that affects outcomes of behavior, concepts, and attitudes (Marsh and Smith, 2000; Knoke & Kulinski, 1982).

Three common characteristics of policy networks are: interdependency, coordination, and pluralism (Enroth, 2011). Interdependency is frequently used to examine multiple infrastructures being connected, creating a system of systems. In a large-scale disaster such as an earthquake, the infrastructure systems designed to function efficiently in normal conditions may instead efficiently spread danger (Comfort, 1999). In actual instances, the relationships are exceedingly complex since they entail multiple interconnections generating an intricate "web" (Rinadi, Peerenboom, and Kelly, 2001). Another characteristic of policy network is coordination, which assumes differences among actors (Axelrod and Cohen, 1999) who share a common goal (Comfort, 2007). In practice, having a "common operating picture", which stresses sharing key information, is necessary to achieve communication and coordination (Comfort, 2007). Finally, pluralism underlying interdependency and coordination, makes it unlikely for a state to enforce its will on a society when policy networks exist (Pierre, 2000). This is because each actor in a network maintains its own beliefs and actions. Nevertheless, this does not imply that the state has lost its governing ability but rather implies that the state could use a policy network to restore it (Enroth, 2011).

As government organizations, or the state actors, take a critical role within policy network, attention is needed to focus on a network approach along with other structural considerations. Klijn and Koppenjan (2000) argued that we must not presume that governments are equivalent to other

actors in the network because they have "*unique resources at their disposal and work to achieve unique goals*". In disaster management, the role of the government organizations is not merely limited to participating in the network but goes beyond participation to shape the field. Acknowledging the network aspects of policy implementation appropriately reflects reality where diverse actors coordinate their activities to achieve a common goal. However, as Ko (2007) argued, developing policy network is not sufficient to facilitate participation nor enhance administrative efficiency. Rather, policy network should be analyzed with rigorous social network analysis methods to investigate the network that reflects dynamic policy environments (Ko, 2007).

2.3 Evolution of Networks

Networks change. Thus, networks of government organizations also tend to evolve over time. Granting the usefulness of network theories in interorganizational networks, an analysis that captures networks at a certain point in time might miss the process of a system moving from stability to change (Salancik, 1995). In other words, networks that merely present a snapshot may not account for the ongoing change of networks and fields. The change in networks over time, or network evolution, is defined as "*series of events with a definable outcome*" (Lenski et al., 1991), more specifically as a "*series of events that create, sustain, and dissolve social structures*" (Doreian and Stokman, 1997). According to such definitions, evolution of networks yields outcomes that can be observed through time.

The dynamics of fields can be detected when there is an external factor that has critical impact on the networks. Such external factors are conceptualized as "exogenous shocks" which destabilizes strategic action fields (Fligstein and McAdam, 2012). Three primary sources of

exogenous shocks are i) invasion of outside groups ii) changes in fields on which a field is dependent ; and iii) macroevents such as war or depression that contribute to destabilizing the broader sociopolitical context in which the field is nested (Fligstein and McAdam, 2012).

Changes in a field induce changes to other fields that are related to them. Such dependencies or interdependencies which create stability in normal conditions may bring forth even more disturbance in times of crisis. This is consistent with Comfort's (1999) argument that infrastructure systems could increase the danger more efficiently because of its high interdependency. Fligstein and McAdam (2012) argue that this most often occurs when there are resource dependencies. A change initiated from a single organization could cause a ripple effect to other fields both proximate and distant. Likely, reorganization of an agency could be a source of exogenous shock that generates changes to other related fields and eventually, the whole network.

Whereas the disruption in a related field initiates change through cascading events, macroevents elicit change to the broader society by impacting diverse fields simultaneously. For instance, large scale disasters impact a wider variety of governments and agencies compared to localized crises. However, as Fligstein and McAdam (2012) noted, the "*mediating dynamics*" are the same, indicating there are **threats or opportunities** that generate **allocation or creation of organizational means** to **interact** with other actors. Likewise, Birkland (2016) argued that while focusing events like large scale disasters do significantly drive disaster policy, policy changes could also be initiated by accumulation of experience. Despite the differentiation made in the range of impacts, the sources of exogenous shocks commonly stimulate the fields composed of network(s) to react to the imposed changes.

2.4 Network Effectiveness in Dynamic Environments

While the common sensical definition of effectiveness entails achievement of desired outcomes or intended results, the operational definition of network effectiveness used in this research needs quite a different approach. This is due to the difficulty of determining desired, intended, or expected 'outcomes' of networks. Since networks are constituted of various actors with different resources and goals, it is far more challenging to determine a desirable state compared to that of a single actor or a few actors. Moreover, particularly in disasters, rapidly changing environments restrain 'expecting' an established outcome. This is because the boundaries of networks are likely to move continuously even by a minimal change in the environment. Defining and measuring network effectiveness requires a more comprehensive view instead of limiting to a few indicators based on commonly accepted ideas of effectiveness.

Network effectiveness is defined as the accomplishment of "***positive network level outcomes*** *that could not normally be achieved by individual organizational participants acting independently*" (Provan and Kenis, 2008). Two important aspects of network effectiveness are flexibility and stability (Provan and Kenis, 2008). Flexibility is necessary in terms of rapid response to the dynamic environment (Provan and and Kenis, 2008). Yet, flexibility which serves well in the shorter time frame may not be as relevant in maintaining the network over time. Stability is crucial with respect to sustainment (Provan and Kenis, 2008). Even without sufficient resources, stability was found to be a leading factor that explained network effectiveness (Provan and Milward, 1995). In this section, literature on factors affecting network effectiveness will be reviewed in association with the concepts of flexibility and stability. Based on this view, operationalized measures of network effectiveness will be derived.

2.4.1 Structural Approach

Provan and Milward (1995) highlighted network integration arguing that central organization reinforces integration and cooperation with its ability to monitor and control the actions and directions of the network. The authors measured network integration with density and centralization[2]. The rationale was that the denser the network, the more communication and interaction between the actors, which tends to bring effectiveness to the network (Provan and Milward, 1995). In contrast, higher centralization was thought to indicate a more efficient and effective network by means of coordination (Provan and Milward, 1995). Later, Provan and Kenis (2008) asserted that the integration of diverse actors into the network relies on the form of network governance to have a positive association with effectiveness. That is, whereas density is related to effectiveness in shared governance networks where authority and power are dispersed across the network, centralization is associated with effectiveness in highly brokered networks, where distribution of authority and power is asymmetric (Provan and Kenis, 2008). Wang (2016) argued that the relation between density and effectiveness was mediated by the size of the network. While in small networks, density contributed to effectiveness because more interactions led to higher degree of trust in larger networks more frequent interactions increased complexity, tension and inefficiency (Wang, 2016).

Provan and Sebastian (1998) focused on the clique overlap, or integration through cliques. A clique is "*a subgroup of actors* ***who are all directly connected to one another*** *and no additional network member exists who is also connected to all members of the subgroup*" (Hawe, Webster,

[2] Density is the proportion of ties that are present out of all possible ties(Hanneman and Riddle, 2005) and centralization characterizes the extent of the cohesion around the focal points(Freeman, 1978).

and Shiell, 2004). Provan and Sebastian (1998) argued that integration through cliques has a stronger positive effect on network effectiveness than integration of the whole network.

Network inner stability was acknowledged as being associated with network effectiveness by promoting development, knowledge diffusion, and persistence of relationships (Turrini et al., 2010). These factors were recognized as deriving higher integration and subsequently, higher network effectiveness (Turrini et al., 2010). Similarly, Wasserman and Faust (1994) stressed the pattern of relationships that sustained within a certain boundary. Some scholars explored this concept further and argued that while inner stability is important within the network core, flexibility of membership produced innovation at the periphery (Provan and Lemaire, 2012).

Overall, research emphasizing the structural factors of network effectiveness drew attention to stability features. Provan and Milward's (1995) argument provides a partial explanation in stating that changes in funding, quick attraction or exit of network members could be detrimental to outcomes of the network. Moreover, multiple levels of structures within a network adds complexity to measuring effectiveness. Nevertheless, flexibility, as well as stability, of structure needs to be considered since it is fundamental to achieving effectiveness particularly in dynamic environments.

2.4.2 Procedural Approach

Network effectiveness could also be measured by various process indicators. While there could be a wide variety of process indicators for effectiveness including trust, commitment to process, shared understandings, and legitimacy (Smith, 2020), this research will focus on shared understandings and meanings throughout the process of network evolution.

One prominent instrument that derives shared understanding is network learning. Comfort (1988) referred to the crisis response network as a "*learning system*" relying on the capacity of the participants to "*generate valid information, facilitate informed choice, and faster timely commitment to action*". Brass and colleagues (2004) noted that organizations that have experienced collaborations in the past are more likely to engage in future collaborations. Provan and colleagues (2007) contended that networks can adjust and evolve through learning. In these arguments it is commonly assumed that learning leads to shared understandings based on which networks make decisions and take action.

Since networks are composed of sublevels of networks that are also connected to other networks/subnetworks, network learning occurs not only within a network but across networks (Smith, 2020). Thus, as Saz-Carranza and Longo (2012) addressed, learning could be associated with both internal and external legitimacy. Internal legitimacy refers to the actors in the network viewing the work of the network as valuable and worthy (Milward and Provan, 2006). On the other hand, external legitimacy indicates the perception of the outside actors on the work of the network (Smith, 2020). By employing various measures to analyze networks, we could infer the existence of network learning, which implies shared understanding among the networks and participating members.

Closely related to network learning, another procedural aspect of network effectiveness could be framed using concepts of collective cognition. Comfort (1994) argued that in crisis management, daily meetings among responders promoted a "*common knowledge base*" on the nature of the task that subsequently enhanced mutual coordination and adjustment. Such a daily sharing of information would most likely occur in the response phase of a crisis where timely action is critical. Moynihan (2008) stressed adoption of a "*common management framework*" like

the Incident Command System (ICS) to facilitate intra-crisis learning. Whether formal or informal, such shared knowledge, or collective cognition, is critical particularly in managing networks in crisis. Here, cognition is specifically defined as "*the capacity to recognize the degree of emerging risk to which a community is exposed and to act on that information*" (Comfort, 2007). The reason why cognition plays an important role in crisis is because it serves as a process by which changing conditions are incorporated and implemented in subsequent actions to manage the crisis (Comfort, 2007). When cognitions of the members in the networks meet, collective sets of knowledge are produced. Weick and Roberts (1993) called it a "*collective mental process*" through which overlapping knowledge elicits actions of the strategic networks. By integrating cognitions of different sorts, dynamic situations can be better assessed. Seeking the linkage between collective cognition and performance contributes to clarifying process perspectives of network effectiveness.

2.4.3 Environmental Factor

The prior section discussed how literature embodied structure and process as an integral factor for network effectiveness. This section reviews the environmental context in which the structural and procedural aspects are situated. A tension exists in the literature over whether environment is considered as "starting conditions" (Ansell and Gash, 2008) versus being called an "authorizing environment" (Rethemeyer and Hatmaker, 2008). In developing their collaborative governance model, Ansell and Gash (2008), conceptualized power/resources/knowledge asymmetries and a prehistory of cooperation or conflict - both of which could be considered environment – as influencing the incentives for and conflicts with participation in a network as starting conditions. Rethemeyer and Hatmaker (2008) deemed that the environment involves intersections of networks at different levels, with the higher levels including the lower levels of

networks and their actors. The continuous influence of environment and the operational context were also reiterated by Emerson, Nabatchi, and Balogh (2012). The authors argued that the system context is not merely the starting conditions but "*a surrounding three-dimensional space*" since external conditions may have an impact on collaboration "*at any point during the life of the collaborative governance regime*" (Emerson, Nabatchi, and Balogh, 2012). Although there is a discrepancy in the degree of focus put on the environment, the common assumption is that environmental factors play an important role in the process of network evolution.

Resource and exchange of resources within and across actors are actively discussed among scholars seeking environments as determinants of network effectiveness. Although in theory, the more resources a network has, the more likely that the network is effective, empirical evidence shows mixed results (Turrini et al. 2010). Provan and Milward (1995) found that the relationship between resources and effectiveness is contingent on other network attributes including network integration, and thus argued that resources were necessary but not sufficient for effectiveness. Fligstein and McAdam (2012) contended that resource dependencies are related to network stability in that strategic action fields with lots of links to other fields are less likely to experience severe crises. In other words, the effectiveness of networks is dependent on their ability to draw on resources using their existing links to other fields.

In complex adaptive systems a niche, or community, relies on the exchange of resources for existence (Holland, 2012). The common features of niche involve *multiplier effects*, meaning that resources do not disappear but are passed from agent to agent, and *recycling*, meaning that agents interacting in intertwined loops convert resources and pass them on (Holland, 2012). Human and Provan (2000) noted that resources were especially important for the success of a network in the early phases when the network is being developed.

Yet, the relationship between resources and network effectiveness is not clear enough to conclude whether a resource is a sufficient condition for network effectiveness. Therefore, the focus should be placed on how resources are being exchanged among the actors in the network that might account for network effectiveness. For instance, frequent exchange of information between central actors within a network may not have a greater impact than central actors exchanging information less frequently with actors at the periphery.

2.4.4 Time Factor

While many scholars recognize structure, process, and environment as major determinants of network effectiveness, time factor has not gained much attention although the dynamics of networks has granted increasing awareness. Smith (2020) argued that scholars should study networks as a dynamic structure utilizing configurational approach. Based on such an argument the author addresses how sequential introduction of value conflicts into a network influences network performance (Smith, 2020). By presenting the configurations of network characteristics in a sequential manner, this research uncovers the effects of network construction occurring through process variables.

Page and colleagues (2018) analyzed a single network over a 7-year period with respect to the variations of value conflicts and the coping mechanisms. The findings indicated that in the early phases of collaboration value conflicts were related to goals and problems whereas in the later phases, process values including accountability and legitimacy gained awareness. Likely, network effectiveness could also be manifested differently over time. Thus, time will be considered as a variable elucidating the relationship between other determinants of network effectiveness.

2.5 Theoretical Frameworks

2.5.1 Complex Adaptive Systems

A common attribute underlying the immune system, ecosystem, market, and government is that these systems have "evolving structure" (Holland, 1992). These systems represent complex adaptive systems, defined as "*systems that have a large number of components, often called **agents**, that **interact** and **adapt or learn***" (Holland, 2006). Each agent has its own internal models which compose the fundamental attribute of the complex adaptive system (Holland, 1992). Based on the interpretive and behavior rules (Argyris and Schön, 1997), they act and anticipate the future (Holland, 1992). Thus, when circumstances change and existing rules are no longer feasible, agents change their rules so that they can survive within the environment. It is through such adaptation and evolution that agents improve their performance (Holland, 2006).

In his book *Signals and Boundaries*, Holland (2012) addresses three properties of complex adaptive systems in search of mechanisms of change. First, universal competitor or global optimum does not exist in complex adaptive systems. As a result of interactions between agents, niche emerges, which is "*a diverse array of agents that **regularly exchange resources** and depend on that exchange for continual **existence***" (Holland, 2012). The presence of niches indicates that the goal of change for individual agents is not optimization but improvement (Holland, 2012). Second, innovation occurs regularly in complex adaptive systems since adaptation through recombination of "building blocks" continues at all levels (Holland, 2012). In the process of developing adaptive mechanisms, innovations occur. Third, anticipation can change the systems. For example, in markets, anticipations of people derive changes to the system whether it is actualized or not (Holland, 2012). Anticipation operates based on internal models and thus, when

an agent anticipates changes in the environment, it is anticipating change in other agents and their models, since the environment includes other agents in the system (Holland, 2012). These properties of complex adaptive systems highlight the relationships between agents with respect to resource, innovation, and anticipation.

What makes it difficult to understand complex adaptive systems is that collective behaviors do not simply emanate from the sum of its parts (Holland, 1992). Accordingly, to comprehend the whole system, we need to understand the interactions among the components. Since diverse agents are connected to each other and are highly interdependent, complexity arises (Page, 2009). Even decisions or actions based on simple rules could generate complex behavior as an aggregate (Holland, 2012). Hence, analyzing the interactions of agents who adapt to the change of environment is the first step towards understanding the evolution of networks, which are composed of complex adaptive systems and are complex adaptive systems themselves.

The interactions between agents in adaptation elucidate how adaptive mechanisms are developed. This process is not only critical to individual agents who rely on their mechanisms in adapting to the environment, but also to the system as a whole, as such "patterned interactions" provide the ground on which complexity could be harnessed (Axelrod and Cohen, 1999). Although the immense number of details make it difficult to understand the dynamics of complex adaptive systems in common terms (Holland, 2012), patterns observed during the course of interactions could clarify the latent mechanisms, which would otherwise be unnoticed.

To identify the patterns of interaction among agents, several key elements need to be incorporated within the study, some of which overlap with the concepts used in theory on networks and fields.

Agents. Agents are the primary unit of complex adaptive systems having “interpretive and behavioral rule” (Agyris and Schön, 1997), “program” (Holland, 2012), “internal model” (Holland, 1992), or “schema” (Anderson, 1999; Stacey, 1996) of their own. Agents correspond to “nodes” in network theories and “actors" in theory of fields (Fligstein and McAdam, 2012). However they are dubbed, all agents interact, or choose not to, with other agents based on the respective rules embedded in their individual systems. As discussed earlier, an agent could be composed of multiple subsystems like the hierarchies of actors that resemble Russian dolls with larger dolls embracing smaller dolls. Agents have “building blocks” (Holland, 1992) that they combine and form a rule to make decisions, act upon, and interact with other agents. When the rule turns out to be incapable of achieving their goals, agents recombine the building blocks and develop new rules and strategies.

Niche. A community within a network (Newman, Barabasi, and Watts, 2006) serves as a primary outset of a more comprehensive definition of niche (Holland, 2012). Since critical elements of niche are diverse agents who regularly exchange resources, assumptions are made regarding the diversity of agents relying on each other’s resources to survive. Moreover, dynamics of niches could be inferred from the contingent actions that are interdependent with one another. One of the universal features of niches is persistent patterns of interactions that remain throughout and beyond the lifetime of agents (Holland, 2012). Niches could be correlated with the concept of the “field” in theory of fields, where boundaries shift usually due to exogenous shocks (Fligstein and McAdam, 2012). Such boundaries involving various “bounded subsystems” (Holland, 2012) provide a rationale for evolution of networks through the development of communities.

Environment. In complex adaptive systems, the environment includes other agents (Holland, 2012). This adds complexity to the systems because the interdependent behaviors of

agents create an environment that is difficult to anticipate. Simply involving one more agent into the system or changing a rule by a single agent could yield massive complexity to the whole system. Page (2009) noted when "*connection, interdependence, diversity, and adaptivity*" are adequately high, even small groups of human adaptations could engender complex behaviors. Thus, along with context and history, various interconnected agents play a critical role in stimulating other agents to adapt to the environment.

Adaptation. In constant efforts to improve their ability in interactions with the environment, agents evolve. An agent who behaves based on a set of rules, evolves towards fitness (Wallis, 2006). The rules, or internal models composed of building blocks are reconstructed to adapt to the changing environment. The rules based on experience of cognitive structure (Anderson, 1999; Stacey, 1996), may also change through learning (Stacey, 1996; Dooley, 1997). In the process of adaptation, useful events are selected then employed as new building blocks (Holland, 1992). Such recombination of existing building blocks orients the complex adaptive system to create new levels of organizations by means of coevolving signals and boundaries (Holland, 2012). When new structures are formed through adaptation, it is often the case that a specialized version of current components is developed (Holland, 2012). Overall, the process of adaptation assumes the existence of feedback loops connected through networks as in ecosystem.

Outcome. As a consequence of continuous adaptation, complex adaptive systems self-organize (Anderson, 1999; Axelrod and Cohen, 1999). It could also be conceptualized as an emergence of a new system with new orders (Mitleton-Kelly, 2003). Since adaptations involving feedback loops occur constantly, it would be less precise to call a state permanent "equilibrium". However, the equilibrium between stability and chaos may be achieved in the transition phase between disorder and order, namely "edge of chaos" (Kauffman, 1993; Lewin, 1999, Stacey, 1996).

2.5.2 Strategic Action Fields

Drawing from diverse scholars' theories on action fields, Fligstein and McAdam (2012) propose a flexible set of concepts to understand how collective actors construct social order through interaction with one another. Central to the theory of fields is the "strategic action field" (Fligstein and McAdam, 2012). A strategic action field is "*constructed **mesolevel social order** in which actors are attuned to and interact with one another"* (Fligstein and McAdam, 2012). This mesolevel social order grounds on a "***shared understanding** about the **purposes** of the field, **relationships** to others in the field and the **rules** governing legitimate action in the field*" (Fligstein and McAdam, 2012). Laumann and Knoke (1987) narrowed the concept and dubbed it a "policy domain", which would be more familiar to the public policy discipline.

How a strategic action field is constituted of smaller strategic action fields is analogous to Russian dolls in which smaller dolls are nested within the larger ones (Fligstein and McAdam, 2012). Likewise, a field can be broken down into smaller sets of fields, which have different degrees of dependency on one another. In other words, even within the same field, change in one sub-field could have tremendous impact on certain sub-fields but not as much in others. However, common to all strategic action fields is that they all have the "potential to effect change" for each other (Fligstein and McAdam, 2012). In other words, all strategic action fields that are linked to one another, either directly or indirectly, are *inter*dependent. This is the very concept that is used to describe policy network regarding their complex arrangements.

A critical feature of strategic action fields is that they are not fixed but are constantly changing (Fligstein and McAdam, 2012). This means that the boundaries of the fields at one point in time cannot be assumed to be the same at other points in time. Moreover, even within a single time point, boundaries could shift according to the "*definition of the situation and the issues at*

stake" (Fligstein and McAdam, 2012). For the actors operating under commonly defined policy goals (Laumann and Knoke, 1987), the policy domain changes according to the situational changes. If we agree that putting the function of social order back into place promptly is an utmost goal after an extreme instability, "field stability" would be what needs to be pursued following a disruption. According to Fligstein and McAdam (2012) field stability is achieved either through imposed hierarchical power or political coalition based on cooperation. Though government organizations are hierarchies themselves, I argue that they also seek stability not only by enforcement but also cooperation after crises.

The concept of action fields cannot be separated from the broader environment in which it emerged and is sustained, and later is disappeared from. As seen from the nature of strategic action fields, their constant interaction with other fields develops new sets of fields, which in turn affects other fields. One notable distinction that helps characterize a field in terms of its environment is identifying "proximate fields" from "distant fields" (Fligstein and McAdam, 2012). Proximate fields refer to strategic action fields that have persistent ties to a certain field and thus, impact the actions of the field at stake. Distant fields, in contrast, are the fields that do not have ties to the field, and so are far from having impact on that field (Fligstein and McAdam, 2012). A change in a proximate field would not be the same as a change in a distant field with respect to exerting influence over one another.

In sum, the framework of complex adaptive system and strategic action fields demonstrate how the research questions are put together and how the components relate to one another (see figure 3 below). To answer the question, *How does government reorganization affect the government's inter-organizational networks and network effectiveness in the dynamic context of disaster?,* the variables are related to the components of complex adaptive system. Agents are

organizations within the disaster management that actively interact with one another. The aggregate of agents forming niche is groups of organizations that form subnetwork level communities. Environments are all the external factors affecting the agents and niches which include other agents. The dynamic context of disasters is assumed to be the environment in which organizations, groups of organizations, and the whole network are affected by and adapt to. Organization and communities create strategic action fields which are likely to change within the dynamic environment. All these factors are thought to be influenced by the exogenous shock, the governmental reorganization. Based on this theoretical framework, next chapter will address the research design.

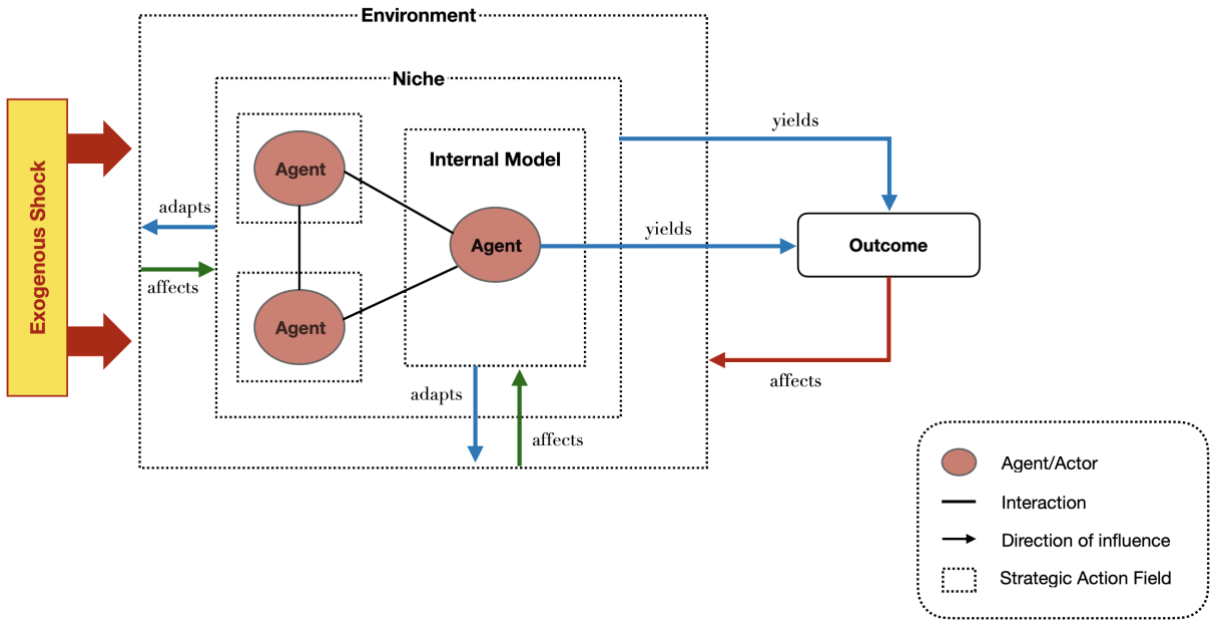


Figure 3. Theoretical Framework

3.0 Research Design

This chapter lays out the research design for this study. First, the comparative case study and pattern matching are introduced, providing a basis for understanding how the research is going to be shaped. Next, details about the case selection and the unit of analysis are described. Then, methods and data are illustrated to present how the analyses are conducted based on the types of data. Finally, validity and reliability of the research is discussed.

3.1 Comparative Case Study

The primary method of analysis is a comparative case study. Case study is defined as "*an intensive study of a single unit for the purpose of understanding a larger class of (similar) units*" (Gerring, 2004). Based on the case study method, a comparative approach is employed comparing the networks of organizations in response to two earthquakes that occurred in Korea in 2016 and 2017. Comparative analysis, applied in case study, tests "*hypothesized empirical relationships among variables on the basis of the same logic that guides statistical method, but in which the cases are selected in such a way as to maximize the variance of the independent variables and to minimize the variance of the control variables*" (Lijphart, 1975). Furthermore, Smelser (1967) asserted that when two or more cases have similarity in terms of crucial variables, the investigator could better analyze the impacts of other variables that could explain the observed differences (Lijphart, 1975).

Paired comparison is a distinct strategy with its similarity to an experiment comparing the impact of a single variable or mechanism on a dependent variable (Tarrow, 2010). Based on existing knowledge, the researcher matches the confounding variables of the cases (Tarrow, 2010). Thus, paired comparison benefits from the descriptive depth of a single case study all the while reducing the risk of determining a variable to be critical with a single case alone (Tarrow, 2010). Yet some scholars critique the comparative method as a mere "heuristic device" (Stretton, 1969). Moreover, comparative study is considered to derive only partial generalization, which is limited in scope and validity (Lijphart, 1975). However, when seen as an intermediary step to theory building, even such limited means of testing and generalizability could contribute to stimulating replications of the analysis in other settings (Lijphart, 1975).

Since this research aims to uncover the interorganizational networks that operate following government reorganization, the case study is inherently descriptive. However, such a comparative case study method does not lack methodological rigor. Although this research does not strictly follow the logic of causal inference, it intends to identify causal mechanisms where "the general knowledge of the world" and "empirical knowledge of how X and Y interrelate" are combined (Gerring, 2004). Despite the descriptive nature of comparative case study, laying out the mechanism from independent and dependent variables articulates the relations between them.

3.2 Pattern Matching

In addition to the comparative case study method, a pattern matching procedure is applied. Pattern matching is a technique that compares empirical patterns with theoretical patterns (Cao, 2007). The "pattern" is conceived as "*an arrangement of occurrences, incidents, behavioral*

actions, or the outcomes of interventions that are apparent in the raw data" (Mills et al. 2009, Almutairi et al. 2014). Thus, by first identifying the patterns observed in data and then matching it with patterns proposed in the literature (Almutairi et al. 2014; Gibbert et al. 2008), pattern matching helps researchers make judgments about the causal status of relationships, which is rather obscure when assessed using cross-case ordinal analysis (Mahoney, 2000).

Campbell (1975) termed "pattern identification" to characterize qualitative analysis which was considered holistic instead of being atomistic (Hak and Dul, 2009). If empirical patterns match the predicted ones based on literature, the internal validity and reliability of the study is enhanced subsequently confirming the propositions or hypotheses (Almutairi et al. 2014; Tellis, 1997). In the process, pattern matching narrows down potential explanations which would otherwise be unable to be eliminated (Mahoney, 2000). Thus, when designed and applied properly, this technique intensifies the analytic rigor of case study.

The proposed steps of pattern matching include i) propositions based on theory before data collection; ii) statement of counter-theory; iii) a case-by-case comparison between dataset and theory versus counter-theory; and iv) a record of hits and misses (Hyde, 2000; Pearse, 2019). Following such steps, this research will provide propositions based on relevant theories which will subsequently be matched with empirical data collected. As a result, the theoretical statement as well as propositions will be elaborated. The process of pattern matching utilized in this research is illustrated in Figure 4 below.

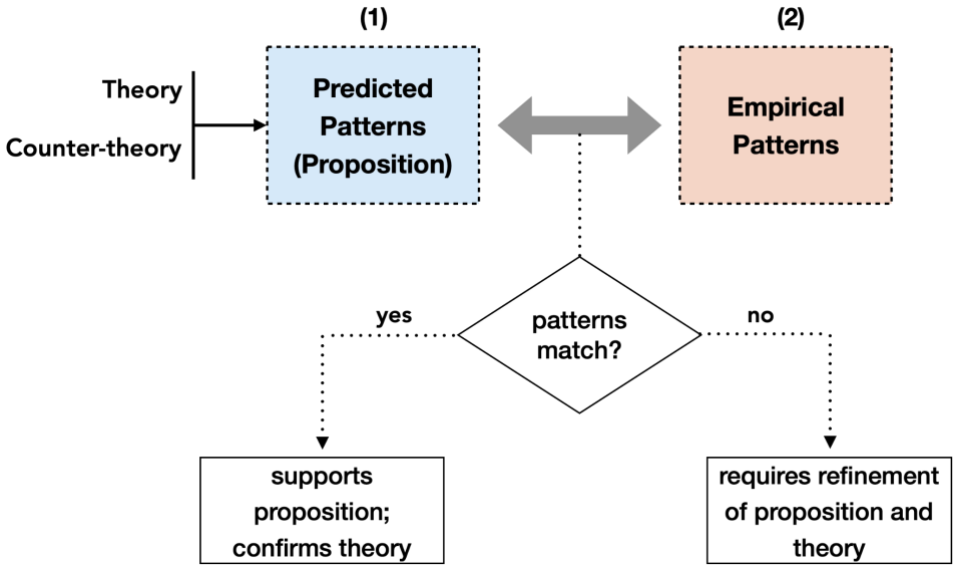


Figure 4. Process of Pattern Matching

3.3 Case Selection: Gyeongju Earthquake (2016) and Pohang Earthquake (2017)

Considering that random sampling is not applicable in selecting a small number of cases, purposive case selection was adopted (Seawright and Gerring, 2008). Purposive case selection facilitates selection of the most suitable cases that contribute to the inferential process (Seawright and Gerring, 2008). Out of possible techniques of case selection, the "most similar method" was chosen in which independent variables of cases are similar except for the independent variable of main interest. Although the two earthquakes occurred a year apart (September, 2016 and November, 2017), the epicenters were located in the cities within the same province - North Gyeongsang Province (see figure 5 below). Furthermore, the subnational level comparison mitigates overdetermination of the dependent phenomenon (Lijphart, 1975) by narrowing the differences in cultural, sociopolitical, and institutional factors that affect the dependent variable of interest.

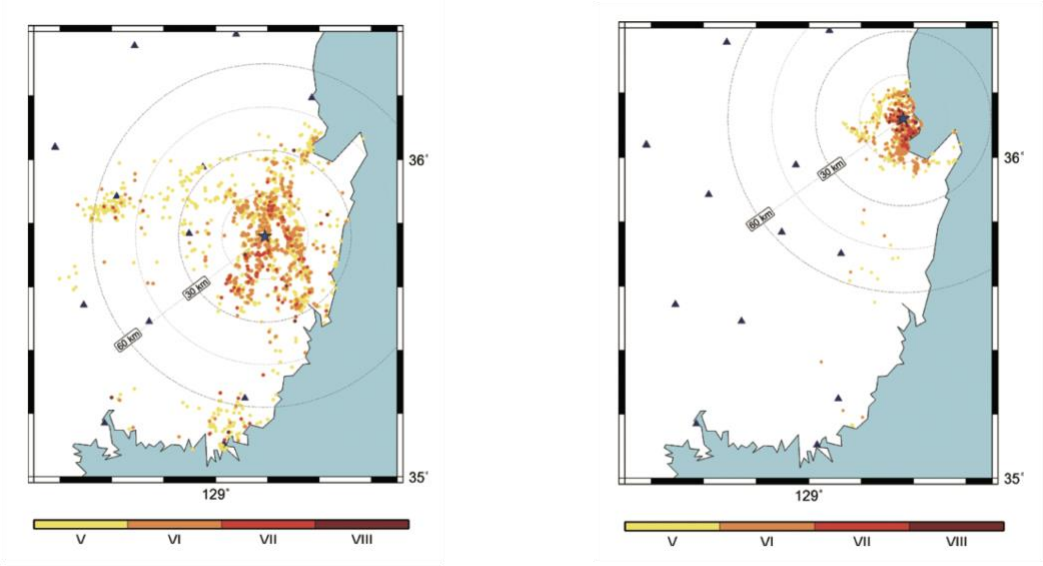


Figure 5. Epicenter and Intensity Distribution of Gyeongju Earthquake and Pohang Earthquake

Source: Korea Meteorological Administration (2018), Pohang Earthquake Analysis Report

Apart from their geographical adjacency and similarity in factors other than the variable of interest - government reorganization - the two cases rank the highest (Gyeongju earthquake, MI 5.8) and the second highest (Pohang earthquake, MI 5.4)[3] with respect to seismic magnitude in Korean history. This may not sound severe when compared to countries like Japan or Indonesia, that have experienced devastating earthquakes. Yet, considering that Korea has not had sufficient recognition and preparedness for earthquakes, these two earthquakes were enough to raise concern of both the government and the public. Figure 6 below illustrates the number of felt earthquakes with magnitudes greater than or equal to 3.0 in Korea from 2005 through 2019. The graph depicts that the number of earthquakes was exceptionally high in 2016 and 2017.

[3] Data source: Korea Meteorological Administration, http://www.weather.go.kr/weather/earthquake_volcano/scalelist.jsp

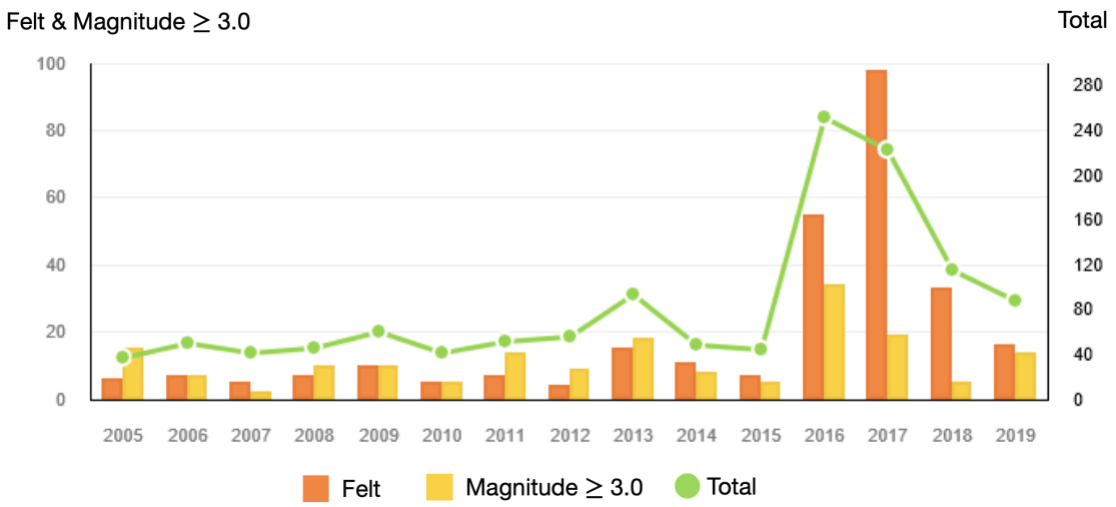


Figure 6. Number of Earthquakes in Korea (2005 ~ 2019)

Source: Korea Meteorological Administration (National Earthquake Comprehensive Information System)[4]

The mayors and governors of the affected local governments are also considered. The mayors and governors of cities and provinces are elected to four-year terms, with a limit of three terms (i.e. maximum of 12 years). At the time of the Gyeongju earthquake, the mayor of the Gyeongju City was Yangsik Choi, who formerly served as a public official in the Ministry of Interior. When the earthquake occurred, he had been in office for 6 years. The mayor of Pohang City in the Pohang earthquake was Gangduk Lee, who had served as a commissioner general in various local police agencies and later as commissioner general of the Korea Coast Guard. At the time of the Pohang earthquake, he had served as mayor for 3 years. Although there are such variances in leadership of the respective cities, the leadership variable is considered to be controlled since these two cities are within the same upper-level government, the North Gyeongsang Province. The Framework Act on the Management of Disasters and Safety states that the governor has authority over the leaders of lower-level governments through diverse institutions.

[4] https://www.index.go.kr/potal/main/EachDtlPageDetail.do?idx_cd=1396 (Accessed April 6, 2022)

The governor of North Gyeongsang Province in both earthquakes was Gwonyong Kim, who served from 2006 till 2018. Therefore, having a single governor across two cases controls the local leadership variable which otherwise could have affected the interorganizational networks.

The important rationale for selecting the two earthquakes for the study is that there was a major reorganization of government agencies between the cases. As discussed in the previous chapter, it is typical for a new administration to rearrange government organizations in Korea for different purposes. Specifically with respect to disaster management, the control of disaster management functions has shifted from the Ministry of Public Safety and Security (MPSS) to the Ministry of the Interior and Safety (MIS) through structural changes. The major difference between the two organizations is that whereas the former had safety and security as its major function by integrating the National Emergency Management Agency (NEMA) and the Korea Coast Guard (KCG), the latter combined two divisions of somewhat distinct functions - internal affairs and safety/disaster management. Such a change in boundaries of functions is identifiable from the name of the respective organizations. While the heads of both the MPSS and the MIS were ministers, the head in control of the disaster management function had changed from minister (MPSS) to vice-minister (MIS). In other words, there is an extra layer of decision making in the MIS since the disaster management function was consolidated with another vice-ministerial level function - internal affairs.

By analyzing each case and then comparing the descriptive measures, the questions on how government reorganization affects interorganizational networks and strategic action fields will be answered (Question 1). Next, the link between government reorganization and network effectiveness will be explored by employing pattern matching techniques (Question 2). Finally,

the evolution of networks will be explored based on change in network configurations divided into 4-week-periods (Question 3).

3.4 Unit of Analysis

The unit of analysis for this research is the network of government organizations in disaster management. The unit of analysis is the entity is the primary focus of the study (DeCarlo, 2018). It is distinguished from the unit of observation, which is the item that is observed, measured, or collected to document the unit of analysis of concern (DeCarlo, 2018). Whereas the unit of analysis is determined by the research question, the unit of observation relies on the method of data collection (DeCarlo, 2018). As denoted in the research question, the primary focus of this research is to identify the networks and how they change, or not, after reorganization. Observation will be conducted at the organizational level as well as at the network level. Besides observing individual organizations to learn about the whole network, interactions among groups of organizations, or the strategic action field, at the mesolevel social order (Fligstein and McAdam, 2012), are considered as a unit of observation. Interviews were conducted with public officials within the Ministry of the Interior and Safety which serves as the control center for disaster management agencies. Since these individuals (interviewees) are representative of their organizations, all are directors in distinct offices and divisions of the MIS, the unit of observation through interview is not individual but organizational.

The unit of analysis and the unit of observation corresponding to the research questions and data collection methods respectively can be summarized as follows:

- Research question: How does government reorganization affect the government's inter-organizational networks and network effectiveness in dynamics of disaster?
    - Unit of analysis: network
- Data collection: network analysis of documents, semi-structured interviews
    - Unit of observation: organization, groups of organizations (sub-network, strategic action fields), network

3.5 Methods and Data

3.5.1 Methods: Social Network Analysis and Semi-Structured Interview

The methods applied are social network analysis of organizational interactions and semi-structured interviews, and topic modeling which uses the interview transcripts as data. These methods are described to consider how these methods could be administered to meet the purposes of this research.

3.5.1.1 Social Network Analysis

The first and foremost method used in this research is social network analysis to identify the network structures and their changes. Network analysis is used by researchers to conceptualize organizational relationships highlighting their linkages, coordination, and collaborations (Hawe et al., 2014; Tichy et al. 1979). Each node in the network represents an organization, mostly central level government agencies. Although local governments and sublevels of government agencies also played active roles within the system, the focus is on central level government organizations

for the purpose of understanding government agencies' responses. The links - edges or ties - connecting the nodes represent the interaction between the organizations. The classifications of interactions are presented in the next section on data collection. To analyze the structure and dynamics of the interorganizational network of the disaster management system, various measurements are employed. The measurements are categorized into node level, sub-network level, and network level.

At the node level, centrality (degree, betweenness, eigenvector), structural holes are used as indicators for measuring important actors in the network. Degree centrality refers to the number of ties a node has. It is measured by the number of nodes that are connected to each node over all possible nodes. The network in this research is undirected so the in-degree centrality (the number of ties it receives) and out-degree centrality (the number of ties it sends) are equivalent. Actors with a greater number of ties may be in an advantageous position because they have many alternative paths to meet their needs (Hanneman and Riddle, 2005). The more ties a node has, the better access to the resources of the network it possesses (Hanneman and Riddle, 2005).

$$Degree\ Centrality\ (v)\ =\ \frac{\Sigma\ [weight\ of\ incident\ links]}{n\ -\ 1}$$

**Degree Centrality of node v is measured where n is the number of nodes in the network*

Eigenvector centrality measures how connected a node is to other nodes with high connectedness. It is calculated by computing the leading eigenvector and then assigning relative scores to all nodes. By definition, eigenvector can only be computed in a symmetric matrix (Bonacich, 1972). Let x be the largest eigenvalue λ of non-negative adjacency matrix A which is

an undirected graph G = (V, E). The eigenvector centrality of node i is equal to the leading eigenvector $x_i$of stochastic matrix N in which the leading eigenvalue is 1 (Du, 2019).

$$Eigenvector\ Centrality\ (i)\ =\ x_i\ =\ \sum_{j \in N(i)} x_j = \sum_{j} A_{ij} x_j$$

** Eigenvector Centrality of node i is measured; where N(i) are neighboring nodes; A is the non-negative adjacency matrix.*

Betweenness centrality is the number of times a node serves as a bridge of the shortest path (geodesic path) between two other nodes. In practice, an actor who is in the position of being a mediator without whom the other two actors cannot be connected, holds communicative power over them. Betweenness measured here refers to node betweenness centrality.[5]

$$Betweenness\ Centrality\ (v)\ =\ \frac{2}{n^2 - 3n + 2} \sum_{s \neq v \neq t} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

** Betweenness centrality of node v is measured where; n is the number of nodes; σ_{st} is the total number of shortest paths from node s to node t; $\sigma_{st}(v)$ is the number of geodesic paths that pass through v (Du, 2019).*

A structural hole, conceptualized by Burt (1992), is a local connection structure of each node. Assuming an efficient relation is one without redundancy, a structural hole is measured by redundancy, efficiency, effective size, constraint, and hierarchy. In this research *efficiency* will be used as an indicator to measure structural holes.

- *Redundancy* is the portion of node *i* in relationship with node *j* that is redundant to the portion of node *i* with other contacts that are connected to *j* as well. High redundancy indicates node *i* is not managing networks efficiently.

[5] Edge betweenness centrality measures the centrality of the edges with the same rationale.

- *Efficiency* is *1* - *Redundancy* summed up for all alters (nodes that are directly connected to a certain node)

At the sub-network group level, the concepts of community (modularity) and clique are employed. Newman and Girvan (2004) measured the quality of network clustering using modularity. The CNM algorithm that they used is a bottom-up agglomerative clustering which repeatedly discovers and merges pairs of clusters to maximize modularity of the community structure (Wakita and Tsurumi, 2007). A clique is a subset of a network where nodes are more intimately linked to one another than others in the network (Hanneman and Riddle, 2005). More specifically, a clique is defined as a maximal complete subgraph composed of three or more nodes (Hanneman and Riddle, 2005). This measure analyzes the cohesive structure of a network. A node can be a member of more than one clique, which could be inspected through clique co-membership and overlap matrices, and hierarchical clustering (Cyram, 2021).

The whole set of network level measurements used in this analysis includes size, diameter, density, and centralization (degree, betweenness). Network size is the number of nodes in the network. Diameter is another aspect of informing how big a network is. The diameter of a network refers to the largest geodesic distance among nodes in the network, where geodesic distance is the number of connections in the shortest possible walk between two actors (Hanneman and Riddle, 2005). Density is the proportion of ties that are present out of all possible ties (Hanneman and Riddle, 2005). If the density of a network is 0.3, it means that 30% of the possible ties actually exist. In practice, this measure could generate insights regarding the speed at which information diffuses through the network (Hanneman and Riddle, 2005). Whereas density describes the overall

cohesion of a graph, centralization characterizes the extent of the cohesion around the focal points. Wasserman and Faust (1994) proposed a graph centralization formula as follows.

$$C_D = \frac{\sum_{i=1}^{g}[\, C_D(n^*) - C_D(n_i)\,]}{max \sum_{i=1}^{g}[\, C_D(n^*) - C_D(n_i)\,]}$$

**Degree centralization of the whole network is measured where; g is the actor degree indices; $C_D(n_i)$ is the point degree centrality; $C_D(n^*)$is the largest degree centrality value.*

$$C_B = \frac{\sum_{i=1}^{g}[\, C_B(n^*) - C_B(n_i)\,]}{(g-1)}$$

**Betweenness centralization of the whole network is measured where; g is the actor betweenness indices; $C_B(n_i)$is the point betweenness centrality; $C_B(n^*)$ is the largest betweenness centrality value.*

3.5.1.2 Semi-Structured Interview

While network analysis meticulously investigates the position and relation of organizations, it is insufficient to analyze how the actors perceive the impact of organizational changes. Hence, semi-structured interviews were conducted to complement network analysis in understanding organizational interactions in disaster management. Along the continuum of structured and unstructured interviews lies semi-structured interview. A semi-structured interview has, to some extent, a predetermined order but allows flexibility directed by the informant (Dunn, 2005). Based on theoretical prior knowledge, questions are set up before the interviews which narrows the topics of primary concern. Thus, interview protocols were developed in advance based on the literature of interorganizational networks, which were refined and adjusted to achieve research purposes. However, not all the questions were strictly followed in the interviews ensuring the flexibility guided by the interviewees.

Another tool utilized with the interview data is topic modeling. The purpose of topic modeling is to provide a story about the text data that might support or inspire hypotheses (Ramage et al., 2009). Topic modeling uses statistical counts to identify topics within documents. Latent Dirichlet Allocation (LDA) distribution is applied for this analysis. The logic is that documents represent distributions of topics and each topic represents a distribution of words (Cyram, 2021). LDA could be understood as matrix factorization (Hofmann, 1999). The word-document co-occurrence is separated into topic matrix and document matrix, which are the probability distributions of non-negative values summed up to one (Steyvers and Griffiths, 2007). The figure 7 below illustrates the topic model in terms of matrix factorization.

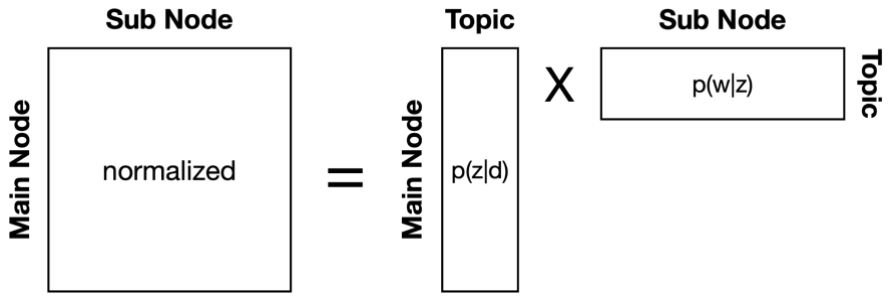


Figure 7. Topic Modeling

*** p(z|d) denotes topic distribution for document(d); p(w|z) denotes word distribution for topic(z)**

Source: Cyram (2021)

3.5.2 Data Collection and Analysis Procedures

The procedures of data collection and analysis for the study are illustrated in detail. The data for network analysis include the government daily reports on the earthquakes, complemented by interview transcripts. For the network analyses, the computer software program *Netminer* was used.

3.5.2.1 Data Collection for Network Analysis: Government Daily Report in Response to Earthquakes

The major source of data for network analysis is the daily report provided by the Ministry of Public Safety and Security (MPSS) and Ministry of the Interior and Safety (MIS). The reports were generated from the day or day after each earthquake and lasted for 24 or 25 days. Since this research investigates system level response to crisis, the time frame is relevant to pursue such immediate response activities. As stated earlier, the MIS incorporated safety and disaster management functions of the MPSS. Thus, in the Gyeongju earthquake, the MPSS took the lead and publicized the daily situational reports of the earthquake, but in the Pohang earthquake, the Disaster Management Office within the MIS generated the reports. Normally, the safety management situations are reported daily by the National Disaster and Safety Status Control Center (hereafter Control Center) but in crisis, the Central Disaster and Safety Countermeasures Headquarter (CDSCHQ) reports the situations and response activities. Whereas the Control Center is a standing office under MIS, CDSCHQ is activated to control and coordinate matters in response and recovery of large-scale disasters prescribed by Presidential Decree (Framework Act on the Management of Disasters and Safety, Article 14. (2018)).

For the Gyeongju earthquake which occurred on September 12, 2016, situational reports were collected from September 13, 2016 through October 7, 2016 (25 days). The largest earthquake struck on September 12 at 20:32, and starting from the next day at 05:00, information on the earthquake and government actions - including damages, injuries, government's response activities, and plans etc. - were reported four times a day.[6] This information flow produced 100 reports, summing to a total of 1229 pages. At first, the Control Center of the MPSS took charge of

[6] The reports were made public at 5:00, 11:00, 17:00, 22:00 on the MPSS website.

the reports but ever since September 14, two days after the strike, CDSCHQ took the lead on preparing the reports.

For the Pohang earthquake, November 15, 2017, the reports were collected from November 15, 2017 through December 8, 2017 (24 days). The largest earthquake occurred on November 15, 2017 at 14:29, and the first report was published at 18:00 on the same day, three and a half hours after the main shake. The contents of the daily reports were roughly similar to those of the Gyeongju earthquake and the reports were published four times a day as well. In sum, 94 reports totaling 857 pages were collected. This time CDSCHQ was established and took charge ever since the first day.

3.5.2.2 Analysis Procedure of Network Analysis

The situational reports were reviewed and coded according to a set of preestablished templates. First, the organizations were coded as nodes each having jurisdictions of their own. Most of the organizations were central level agencies along with some provincial and city level governments. The interactions between the organizations were coded as edges, or ties. The types of interaction were classified into 8 categories.[7] The interactions between the organizations were coded only when a name was explicitly stated in the report. Thus, if the report stated there was coordination between 'MIS and local governments' it was not coded since the specifics about the local governments, such as which level of governments, was not clarified in such a general term. The interactions were coded under the specified dates but the weight, or the number of interactions, between two organizations could be more than one on a single day if multiple types of interaction

[7] Initially, it was coded in 16 categories but as with rounds of data cleaning it was eventually narrowed down into 8. However, the transaction numbers assigned at the beginning were not changed to avoid confusion in the process of data cleaning.

(i.e. transaction) occurred on the same day. The network is undirected which means there exist no arrows noting source and target. Therefore, the organizations have symmetric ties (interactions).

For the analysis, network analysis program *Netminer Version 4.4.3* was used (Cyram, 2021). This software combines the social network analysis methods with modern network visualization techniques (Cyram, 2021). With the comprehensive network measures and models, the data, coded in Microsoft Excel were analyzed in terms of various network measures - degree centrality, betweenness centrality, eigenvector centrality, structural hole (efficiency), community (modularity), clique, degree centralization, and betweenness centralization. First, the whole network dataset for each earthquake case was run, generating a static picture of the overall response network within the set timeframe. Then, the network datasets were segmented into Week 1 to Week 4. Since the time frames of the Gyeongju earthquake and Pohang earthquake lasted 25 days and 24 days respectively, the frequency of interaction in Week 4 was smaller than other weeks. Dividing the time frame into smaller pieces not only helps to identify the evolution of networks within the cases but also allows a more detailed comparison across the cases based on the specified time frame.

3.5.2.3 Data Collection for Semi-Structured Interview

In addition to the structural layout and changes of the interorganizational networks observed through the government reports, transcripts of semi-structured interviews with public officials in the Ministry of the Interior and Safety served as data to comprehend how the disaster management system operated and how it is affected by the changes of environment. From the verbal statements of the public officials at the core of the disaster management system, the actual and perceived changes over time could be analyzed. Also, since there are certain limits to what formal documents the government could provide, interviews contributed to uncovering important

factors that might have impacted networks but were not observed in formal documents. Particularly interviews were considered the primary source of data to elicit answers to questions on shared understanding about inter-organizational networks.

The selection of the interviewees was done through purposive sampling to gain information from knowledgeable experts within the field of disaster management. The interviewees belonged to nine different divisions of the Office of Disaster and Safety Management led by the Vice Minister of the Interior and Safety. The length of time they worked in the field of disaster and/or safety management ranged from 15 months to 21 years (median: 9 years). Eight interviewees out of the 11 had more than three years of experience in the field, which was thought to provide sufficient knowledge and experience associated with the changes in the system over the past few years - especially with the earthquake cases. There is no cap on how many informants are required for a purposive sample, but according to Seidler (1974), five informants are necessary for the data to be reliable. Moreover, the concept of "information power" guided the planning of the sample size (Malterud and Guassora, 2016). Out of the five items that were suggested to have an impact on information power, the study aim, sample specificity, and analysis strategy supported the consideration of sample size of this research.[8] The aims to explore mesolevel social order; requirement of adequate knowledge specific to the particular field; and the middle ground between in-depth case and exploratory cross-case analysis led to determine that the 11 interviewees would be appropriate to present patterns of interaction while holding information power.

Interviews were conducted from November 27, 2019 through December 27, 2019 taking place at the interviewees' offices or nearby locations of the Ministry of the Interior and Safety in

[8] Five items having impact on information power are: 1) breadth of the study aim 2) specificity of experiences, knowledge, or properties of the sample 3) existence of established theory 4) quality of dialogue 5) analysis strategy: in-depth case or exploratory cross-case analysis (Malterud and Guassora, 2016).

Sejong-si or the Government Complex in Jongno-gu, Seoul. The average length of time of the interviews was approximately 50 minutes, which were recorded on the consent of the interviewees prior to the interview. Questions were developed based on theoretical concepts from network literature, the specific questions about the interaction among organizations were derived from Laumann and Knoke (1987). The questions associated with the change of environment were asked specifically about the past six years to focus on the environmental changes in recent years. The interview process was approved by the Institutional Review Board of University Pittsburgh prior to the interviews (October 14, 2019) under the exempt category *(2)(i) Tests, surveys, interview, or observation(non-identifiable)* (STUDY19020321).

Table 1. Affiliation of Interviewees

Office	Number of Interviewees
Public Safety Policy Office	2
Disaster Management Office	2
Disaster and Safety Management Headquarter	1
Disaster Management Cooperation Office	4
National Disaster and Safety Status Control Center	2
Total	11

Table 2. Summary of Data, Methods, and Measurements of Analysis

<table>
<tr><th>Data</th><th>Methods</th><th colspan="3">Measurement</th></tr>
<tr><td rowspan="2">Government Report</td><td rowspan="2">Social Network Analysis</td><td>Network Level</td><td>Sub-network Level</td><td>Node Level</td></tr>
<tr><td>Size
Diameter
Density
Degree centralization
Betweenness centralization</td><td>Community (modularity),
Clique</td><td>Degree centrality
Betweenness centrality
Eigenvector centrality
Structural hole</td></tr>
<tr><td colspan="2">Semi-Structured Interview</td><td colspan="3">Topic modeling: Topic distribution for document,
Word distribution for topic
Pattern matching: common information, communication system, joint activities</td></tr>
</table>

3.6 Validity and Reliability

Assessing the validity and reliability of research is critical to elicit accurate results and to ensure sound and replicable data (Mohajan, 2017). The validity looks at whether the research measures what it intends to measure (Golafshani, 2003). Among different types of validity, internal validity refers to the validity of the research itself while external validity indicates the generalizability of the result to other persons, settings, and times (Drost, 2011). In qualitative research, using certain procedures to appraise the accuracy of the research finding is considered as checking validity (Mohajan, 2017).

Threats to internal validity occur when there is inadequate knowledge during data collection, analysis and/or interpretation (Mohajan, 2017). To overcome such threats, triangulation - collecting information from various sources, member checks - asking the interviewees to affirm

what they have stated, and peer examination - data and findings reviewed by peers outside the field but with enough background information - could be implemented (Zohrabi, 2013). In accounting for external validity, generalization to a well-explained target population needs to be distinguished from generalization across populations (Drost, 2011). Yin (1994) stated that external validity could be obtained through theoretical relationships, in which generalizations are made (Tellis, 1997).

Reliability refers to the extent to which measurements are replicable (Drost, 2011). In other words, it is related to the stability of findings by employing stable measurement over different conditions (Nunnally, 1978). Internal reliability indicates the consistency of collecting, analyzing, and interpreting the data (Zohrabi, 2013). Thus, when equipped with internal reliability, similar findings will be drawn when an independent researcher reanalyzes the information provided by the original researcher (Zohrabi, 2013). External reliability relates to the replication of the study, which is determined by the status of the researcher, the choice of informants, the social situations and condition, analytic constructs and premises, and the methods of data collection and analysis (Zohrabi, 2013).

Threats to reliability occur due to the lack of clear and standard instructions, failing to provide all alternatives, ambiguous description of measurement instruments etc. (Kerlinger, 1973; Fink and Kosecoff, 1985). In studies involving qualitative approaches, it is considered demanding to derive identical results, and thus Lincoln and Guba (1985) and Merriam (1998) suggested "dependability" of results. The dependability is assured by explaining the process and phases of inquiry explicitly; collecting information from various sources (triangulation); describing in detail the data collection, analysis, and achievement of themes and results.

To reduce threats to validity and reliability, this research applies several mechanisms. First, to enhance internal validity, pattern matching is carefully applied. It is asserted that internal

validity of a case study can be intensified if rival explanation patterns are developed and matched (Cao, 2007). In addition, use of different sources - government reports and interviews - are employed to guarantee accuracy and alternative explanations (Stake, 1995; Tellis, 1997). Second, external validity is increased by probing the theoretical relationships, which contributes to generalization (Yin, 1994). Third, internal reliability is strengthened by building rules and procedures in the protocols. Specific explanations of the process are provided in each phase of the inquiry to make the results dependable (Lincoln and Guba,1985; Merriam, 1998). Moreover, several rounds of data cleaning and recoding were done to reassure the consistency of the findings. Finally, external reliability is sought by carefully choosing informants and acknowledging social situations and conditions. Although it would be difficult to hastily confirm the research's replicability in other settings, explicit presentation of the refined process of the inquiry would allow researchers to apply the process to similar situations and provide insights into extended studies. This conforms to constructivism which views knowledge as socially constructed, which is likely to change contingent to circumstances (Golafshani, 2003).

This chapter addressed how the study is designed by providing both overall picture and details about data and methods. It was identifiable that selection of the two earthquake cases was relevant and timely considering the trend and significance of earthquakes that occurred in Korea. Social network analysis and semi-structured interviews were pertinent as methods to reveal interorganizational networks. Based on this research design, next chapter will illustrate in detail the background, characteristics, and social impacts of the two earthquake cases. Then the starting conditions which served as the environment at the time of the disasters will be identified.

4.0 The Cases and Starting Conditions

This chapter describes the selected earthquake cases to grasp the conditions under which the earthquakes occurred. The overview of the earthquakes provides the backgrounds in which the earthquakes took place and discusses the characteristics and social impacts of the earthquakes. Next, the starting conditions that could have affected the disaster response are delineated, generating both static and dynamic profiles of the disaster management systems of Korea that operated during the earthquake cases.

4.1 Overview of the Two Earthquake Cases

4.1.1 Increase of Earthquakes in Korea

Korea has been known to be comparatively safe from earthquakes in contrast to neighboring countries like China or Japan which are located at the boundaries of tectonic plates. For this reason, the two earthquakes in 2016 and 2017 dismayed the whole country, although physical damages mostly occurred around the southeastern part of Korea peninsula. Table 3 below indicates the list of earthquakes in Korea greater than or equal to Richter Magnitude Scale (M_L) of 5.0. The Gyeongju earthquake in 2016 was the largest with $5.8M_L$ followed by Pohang earthquake in 2017 with $5.4M_L$. Six out of eight earthquakes in the list occurred within the past two decades, except for two, the Sangju and Hongseong earthquakes, which took place in 1978. This pattern calls for attention to possible earthquakes in the near future, implying that Korea is no longer in a

safety zone from large scale earthquakes. The map of Korea in figure 8 points to the locations of earthquakes, each corresponding to the numbers assigned in the table. While the largest three earthquakes are centered around the southeastern region, places such Sangju and Taean are located in the western part of Korea, nearer to the capital of Korea - Seoul - where almost one fifth of the entire population lives.

Table 3. List of Earthquakes in Korea

No.	Name	Date and Time(KST)	Magnitude (M_L)	Location
1	2016 Gyeongju earthquake	09-12-2016 20:32:54	5.8 (5.4 M_W)[9]	Gyeongju, North Gyeongsang
2	2017 Pohang earthquake	11-15-2017 14:29:32	5.4 (5.4M_W)	Pohang, North Gyeongsang
3	2004 Uljin earthquake	05-29-2004 10:14:24	5.2	Uljin County, North Gyeongsang
4	1978 Sangju earthquake	09-16-1978 02:07:06	5.2	Sangju, North Gyeongsang
5	2014 Taean earthquake	04-01-2014 04:48:35	5.1	Taean County, South Chungcheong
6	2016 Ulsan earthquake	07-05-2016 20:33:03	5.0	Dong District, Ulsan
7	2003 Ongjin earthquake	03-30-2003 20:10:53	5.0	Ongjin County, Incheon
8	1978 Hongseong earthquake	10-07-1978 18:19:52	5.0	Hongseong County, South Chungcheong

Source: Korea Meteorological Administration

https://www.weather.go.kr/weather/earthquake_volcano/scalelist.jsp

[9] This shows in seismic magnitude scales which describe the overall strength or size of an earthquake. Seismic magnitude scales differ from seismic intensity scales which classify the intensity estimated at a given location (Wikepedia, https://en.wikipedia.org/wiki/Seismic_magnitude_scales, accessed March 15, 2021).

Figure 8. Locations of Earthquakes in Korea

Image created by the author using *MapCustomizer*[10]

4.1.2 Characteristics and Social Impacts of Gyeongju and Pohang Earthquakes

On September 12, 2016, a mainshock took place in southwestern area of Gyeongju with a magnitude 5.8. Constant aftershocks followed and they lasted until 12 days after the mainshock (MPSS, 2017). This was the largest earthquake ever since the observation of earthquakes began and the shakes were felt by people throughout the country. The depth of the epicenter was 15 km from the surface which was rather deep compared to the average depth of earthquakes larger than magnitude of 5.0, which is 8.16 km (MPSS, 2017). Approximately one year and two months after

[10] Map data © OpenStreetMap (https://www.openstreetmap.org/) contributors, ODbL (https://opendatacommons.org/licenses/odbl/1.0/);
https://www.mapcustomizer.com/map/Large%20Earthquakes%20in%20Korea (accessed April 7, 2022)

the Gyeongju earthquake, on November 15, 2017, the Pohang area was hit by a mainshock of magnitude 5.4. As in Gyeongju, aftershocks lasted 10 days from the mainshock. However, the number of aftershocks was lesser than that of Gyeongju (See figure 9). One major aftershock of the Pohang earthquake ensued even after 3 months - on February 11, 2018 with a magnitude of 4.6 (MIS, 2018). The depth of the epicenter was 7 km, which is approximately half the depth of the epicenter in the Gyeongju earthquake. This implies that the felt magnitude could have been higher than the actual magnitude (M_L**)**. Table 3 above explicates such phenomena indicating the same seismic magnitude scale (M_W) of 5.4 for both earthquakes.

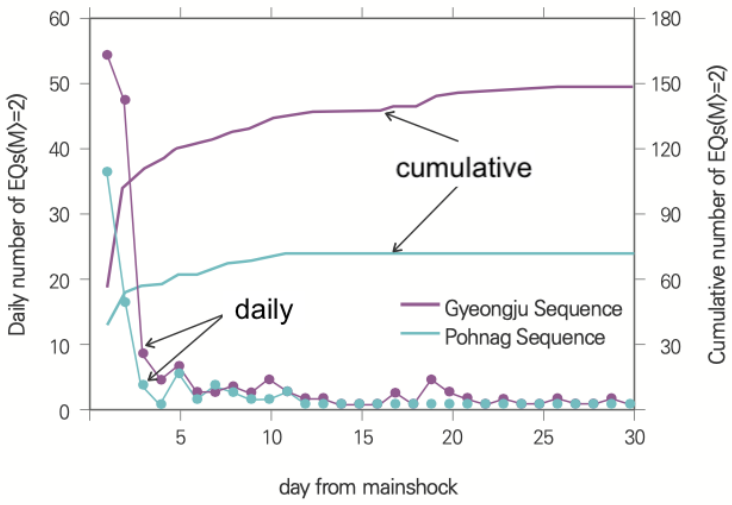


Figure 9. The Trend in Number of Aftershocks of Gyeongju and Pohang Earthquake

Source: The Ministry of the Interior and Safety (2018) (original data from Korea Meteorological Administration)

The sociocultural impacts of the earthquakes were noticeable in both cases. In the Gyeongju earthquake, the impact came as an even larger disturbance without knowledge and prior experience with earthquakes. Thus, not only the citizens but the government faced challenges in

dealing with the disaster as well. The government reports revealed that numerous injuries were due to people jumping off from high places while evacuating. Such problems occurred since there was a lack of education or training about evacuation in earthquakes. Evacuation behavior was observed to be improved when residents faced the next earthquake a year later. The National Fire Agency reported that the number of emergency calls (119) within 30 minutes after the shake was 5,973, which was approximately half the number following the Gyeongju earthquake, 12,995 calls. The decline in calls was assessed to be due to the government's rapid response in communicating with the citizens through emergency text alert (Cellular Broadcasting System, CBS).[11] Moreover when Handong Global University, located in Pohang was affected by the earthquake, almost 4,000 people evacuated within 10 minutes while pieces of blocks were falling off from the building due to the shake. Such rapid action was attributed to 4 rounds of evacuation training after the Gyeongju earthquake.[12] The College Scholastic Ability Test, comparable to SAT in the US, which was planned to take place on November 16 was delayed one week to avoid safety issues that might follow.

A major concern was associated with the nuclear power plants and the radioactive waste disposal sites which are highly concentrated in the southeastern part of Korea. South Korea is known to be a country with the highest density of nuclear reactors (the number of reactors per square mile) in the world.[13] As seen in figure 10, Wolsong, Shin Wolsong, Kori, and Shin Kori nuclear power plants are adjacent to both Gyeongju and Pohang. In the Gyeongju earthquake, press releases were continuously distributed stating that the safety nuclear power plants were not

[11] https://www.sisajournal.com/news/articleView.html?idxno=172251 시사저널 '포항 지진 대응, 1 년 전과 달랐다' 11.18. 2017 이민우 기자 (accessed March 16, 2021).
[12] Ibid
[13]https://www.eia.gov/todayinenergy/detail.php?id=44916#:~:text=South%20Korea%2C%20which%20is%20about,square%20mile Today in Energy 'South Korea is one of the world's largest nuclear power producers' August 27, 2020 (accessed March 16, 2021).

affected by the earthquake. This was based on a safety inspection held by the Nuclear Safety and Security Commission, that inspected earthquake measurements (peak ground acceleration PGA)[14] and after actions taken by Korea Hydro and Nuclear Power (MPSS, 2017). However, concerns among the public did not wane. In the Pohang earthquake, the Nuclear Safety and Security Commission made efforts to communicate with the public through blogs, Twitter, Facebook, websites etc.

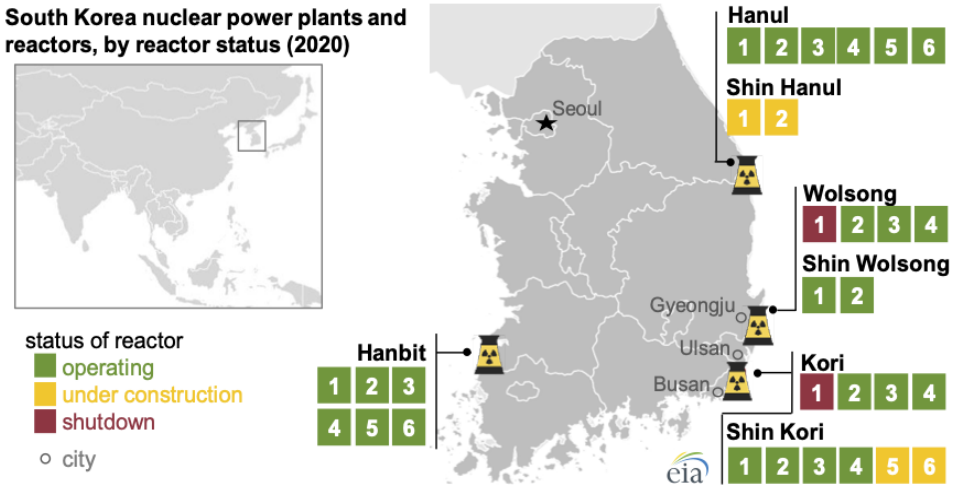


Figure 10. Locations of South Korea Nuclear Power Plants

Source: U.S. Energy Information Administration, International Atomic Energy Agency[15]

Although the death toll was at zero in both earthquakes, numerous injuries and types of economic damages were reported. According to a government report, there were 23 injuries in the Gyeongju earthquake and 92 injuries in the Pohang earthquake. The number of residents who experienced damage from the earthquakes were 111 in the Gyeongju earthquake and 1,797 in the

[14] Peak Ground Acceleration is the maximum ground acceleration during earthquake shaking at a certain location https://en.wikipedia.org/wiki/Peak_ground_acceleration#:~:text=Peak%20Ground%20Acceleration%20(PGA)%20is,site%20during%20a%20particular%20earthquake. (accessed March 16, 2021) .
[15] https://www.eia.gov/todayinenergy/detail.php?id=44916 (accessed March 17, 2022)

Pohang earthquake. Damages calculated were approximately 10 million in USD in the Gyeongju earthquake and approximately 50 million USD in the Pohang earthquake.[16] The discrepancy in the scale of damage was due to several factors. One is the density of the population in respective areas. The epicenter of the Gyeongju earthquake was in a suburban area where 5,181 residents were living within 122 km^2 area. In contrast, the epicenter of Pohang earthquake was located in a small town called Heunghae-eup where 35,000 residents were living within 105 km^2.[17] Other factors were mostly geographical, including the fact that the Pohang earthquake showed both vertical and horizontal moves whereas the Gyeongju earthquake had mainly horizontal moves. Also, as was mentioned earlier, the epicenter was deeper in Gyeongju which might have affected the differences in damages.

Both Gyeongju and Pohang areas are abundant cultural heritage reserves and thus, the damages resulting from the earthquakes became a critical problem with respect to preserving historically important properties. This impact was particularly vivid in the Gyeongju case where 100 cultural heritage reserves in regions including North Gyeongsang province, South Gyeongsang province, Ulsan metropolitan city, and Daegu metropolitan city needed restoration (MPSS, 2017). Moreover, approximately 10 per cent of Hanok, a Korean traditional house, in Gyeongju was influenced by the earthquake. In the Pohang earthquake, 32 cultural heritage reserves were affected in North Gyeongsang province and Daegu metropolitan city (MIS, 2018). These damaged reserves were also linked to economic damages since the number of tourists decreased significantly right after the earthquakes.

[16] http://news.kmib.co.kr/article/view.asp?arcid=0011958626 국민일보 '[그래픽] 포항, 경주 지진피해 비교', December 6, 2017 (accessed March 16, 2021).
[17] http://www.hani.co.kr/arti/society/society_general/819533.html 한겨레 '포항지진 피해가 경주지진보다 큰 5 가지 이유' 이근영 오철우 기자, November, 17, 2017 (accessed March 16, 2021).

Overall, the earthquakes in the two cities had somewhat distinct properties geographically, leading to differences in the degree of influence deriving from the earthquake. Still, located in the same province, North Gyeongsang, the two cities share a lot of common social factors that make the comparison valid. This commonality allows the research to minimize the effects of alternative factors that might have influenced the network of government organizations, which is the main focus of the study.

4.2 Starting Conditions

In this section, the factors that might affect the network in response to disaster will be described. In complex adaptive system, the interdependency between agents makes it difficult to identify the environment as a static feature. In fact, the environment changes as the agents and groups of agents change. Thus, this section draws on the concept of "starting conditions" as Ansell and Gash (2008) addressed in developing the collaborative governance model. These initial conditions will be linked to the dynamics of the environment in later chapters by analyzing the networks of the respective cases and comparing the two. Consequently, whether these starting conditions became "authorizing environments" as noted, will be investigated.

4.2.1 Power, Resource, and Knowledge Asymmetries

According to Ansell and Gash (2008), when certain stakeholders lack capacity, organization, status, or resources, the process of collaborative governance is likely to be wielded by those who are affluent with those properties. Since power and resources in government agencies

are largely dependent on and shaped by the established systems, identifying the disaster management system, institutions and policies helps to understand the disproportionate resources among the organizations.

4.2.1.1 The Disaster Management System of Korea

The primary legal basis for the disaster management system is the Framework Act on the Management of Disasters and Safety (Framework Act hereafter) [*Enforcement Date December 10, 2020] [Acts No.17479, August, 18, 2020, Amendment by Other Act*]. It provides the picture of how the system as a whole is arranged, which organizations lead what kinds of tasks. Hence, we can identify the allocation of power, resources, and knowledge by reviewing the legal provisions. Although the law has gone through several amendments, the overall structure and contents has not changed significantly. Unless otherwise noted, the provisions referred here are the most current.

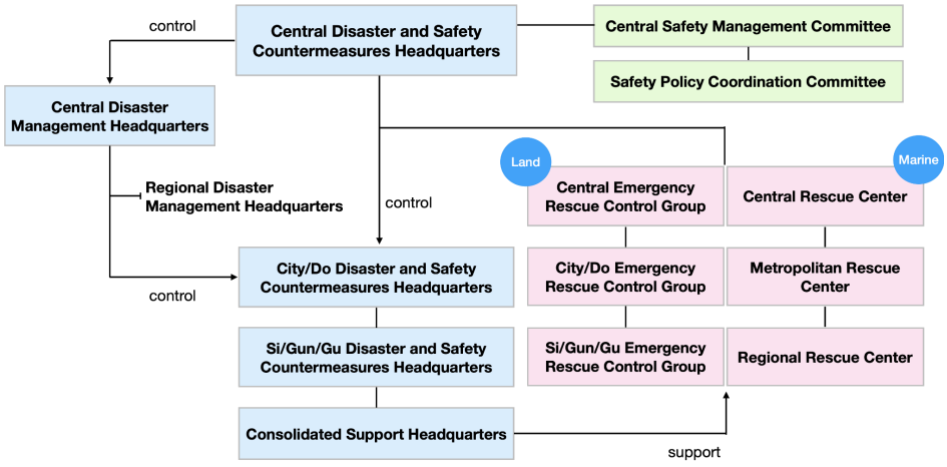


Figure 11. Disaster Management System of Korea

Figure 11 above illustrates how the Korean disaster management system is structured and operates. First, the Central Disaster and Safety Countermeasure Headquarters (CDSCHQ) has the

authority to control and coordinate disaster management (Framework Act, Article 14). The head of CDSCHQ is the Minister of the Interior and Safety (MIS) and the vice head is the Vice Minister of the MIS. The Prime Minister may take over the authority of the head when a government-wide integrated response is necessary. In such cases, the Minister of the MIS serves as the vice head of CDSCHQ (Framework Act, Article 14(4)). Central Disaster Management Headquarters (CDMHQ) is led by the head of disaster management supervision agencies. Disaster management supervision agency refers to an agency that supervises the management of disaster when a certain disaster falls into the category closely related to their tasks. For instance, if a disaster occurs abroad, the Ministry of Foreign Affairs is the disaster management supervision agency. If there is an outbreak of infectious disease, Korea Disease Control and Prevention Agency becomes the disaster management supervision agency. The head of CDMHQ can request other related disaster management agencies "*to take administrative or financial measures, to dispatch their employees or to provide any other necessary support*" (Framework Act, Article 15-2). Disaster management agency refers to central administrative agencies, local governments, local administrative agencies, public institutions, public organizations, and agencies prescribed by Presidential Decree that perform disaster management affairs (Framework Act, Article 3.5).

The CDSCHQ and CDMHQ have authority over their local/regional counterparts. The City/Do DSCHQ is led by Mayor/Do Governor and Si/Gun/Gu DSCHQ by the head of Si/Gun/Gu. At a disaster scene, Consolidated Support Headquarters could be established to control, coordinate and support tasks (Framework Act, Article 16(3)). The consolidated support headquarters should cooperate with the Si/Gun/Gu emergency rescue control group associated with emergency rescue activities (Framework Act, Article 16(3)). The Central Safety Management Committee is established under the jurisdiction of, and chaired by the Prime Minister to deal with extensive

matters associated with disasters and safety management (Framework Act, Article 9(1)). The Safety Policy and Coordination Committee is formed under the Central Committee to review the agenda before submitting to the Central Committee (Framework Act, Article 10(1)). The chair of the committee is the Minister of the Interior and Safety, and the committee members are appointed by the chairperson among the vice ministers (or public officials of vice-ministerial level) of central administrative agencies (Framework Act, Article 10(2)).

To deal with matters related to emergency rescue, the Central Emergency Rescue Control Group (CERCG) is established under the National Fire Agency (NFA) and led by the Administrator of NFA (Framework Act, 49(1),49(2)). When needed, the head of CERCG can request related agencies and organizations to send personnel to sustain mutual assistance systems between the emergency rescue and relief support agencies (Framework Act, 49(3)). As with other headquarters, a corresponding Local Emergency Rescue Control Group may be established, which is directed by the head of fire headquarters (City/Do) or the chief of fire station (Si/Gun/Gu)(Framework Act 50(2)). In disasters that occur on oceans, Central Rescue Center, Metropolitan Rescue Center, and Regional Rescue Center would be established (Act on the Search and Rescue, etc. in Waters, Article 7). The Central Rescue Center is established in the Korea Coast Guard, Metropolitan Rescue Center in regional coast guard headquarters, and Local Rescue Headquarters at coast guard stations (Act on the Search and Rescue in Waters, Article 5(1), 5(2)). However, the rescue and relief activities on inland waters is the responsibility of the National Fire Agency to organize and operate an EMS team (Act on the Search and Rescue, etc. in Waters, Article 7(2)).

Emergency rescue and relief support agencies prescribed by Presidential Decree are the agencies that have human resources, equipment, operation systems etc. for emergency rescue and

relief services (Framework Act, Article 3.8). At the central level it includes, the Ministry of Education, the Ministry of Science and ICT, the Ministry of National Defense, the Ministry of Trade, Industry and Energy, the Ministry of Health and Welfare, the Ministry of Environment, the Ministry of Land, Infrastructure and Transport, the Ministry of Oceans and Fisheries, the Korea Communications Commission, the National Police Agency, the Korea Meteorological Administration, and the Korea Forest Service (Enforcement Decree of the Framework Act on the Management of Disasters and Safety, Article 4.2). These agencies work closely with the Central and Local Emergency Rescue Control Group.

4.2.1.2 Institutions and Policies

There are several institutional measures that associate the agencies to work with each other. The Framework Act stipulates Government joint safety inspections, for which the Minister of the Interior and Safety organizes an inspection group (Framework Act, Article 32(1)) The Minister of MIS could request other disaster management agencies to dispatch personnel (Framework Act, Article 32(2)). Also, the disaster preparedness drills are to be conducted annually by the MIS, central administrative agencies, local governments, and emergency rescue agencies (so called "drill supervision agencies") together with related agencies - disaster management agencies, emergency rescue and relief support agencies, and military units (Framework Act, Article 35(1)).

Dealing specifically with natural disasters, the Countermeasures Against Natural Disasters Act [Enforcement Date September 12, 2020] [Act No.17472, August 11, 2020, Amendment by other Act] (Natural Disasters Act hereafter) describes the investigation and analysis of causes of disasters, information system, central and regional emergency support system. The heads of disaster management agencies can investigate the causes of natural disaster in facilities under their own jurisdiction (Natural Disasters Act, Article 9(1)). The Minister of the Interior and Safety or

the head of local governments can investigate directly the causes of a disaster, develop measures mitigation, and then notify the results to the related disaster management agencies and local governments (Natural Disasters Act, Article 9(3)). This is also declared in the Framework Act, Article 69(1).

Each disaster management agency must develop and operate a disaster information system, and the head of each agency can request other disaster management agencies to provide data when necessary (Natural Disasters Act, Article 34(1), 34(2)). Then the Minister of the Interior and Safety institutes and operates a comprehensive disaster information system, which would serves as a linkage among all disaster management agencies (Natural Disasters Act, Article 34(3)). The comprehensive information system allows any disaster management agency to enter information about the current status of operations and recovery in real time (Natural Disasters Act, Article 34(4)). Such information and communication systems for disaster management are also stated in the Framework Act, Article 74, which means the information system could be utilized in social accidents as well. It is stipulated in the Framework Act, Article 74-2, that disaster management agencies, emergency rescue agencies, and emergency rescue and relief support agencies share disaster management information.

When a natural hazard event occurs, the heads of central administrative agencies are responsible for formulating emergency support plans on matters within their jurisdiction (Natural Disasters Act, Article 35(1))[18]. Those agencies form the Central Emergency Support System cooperating with relevant agencies in preparation and in response (Natural Disasters Act, Article

[18] The agencies stated in the Natural Disasters Act: The Ministry of Science and ICT, Ministry of National Defense, Ministry of the Interior and Safety, Ministry of Culture, Sports and Tourism, Ministry of Agriculture, Food and Rural Affairs, Ministry of Trade, Industry and Energy, Ministry of Health and Welfare, Ministry of Environment, Ministry of Land, Infrastructure and Transport, Ministry of Oceans and Fisheries, the Public Procurement Service, Korean National Police Agency, Korea Coast Guard.

35(2)). The head of CDSCHQ may organize a supporting team with related central administrative agencies and send the team to the disaster sites (Natural Disasters Act, 35(5)). The head of local government and disaster management agencies having jurisdiction over City/Do and Si/Gun/Gu also need to develop emergency support plans and operate the Regional Support System (Natural Disasters Act, Article 36).

4.2.2 Prehistory of Cooperation or Conflict

Experiencing disasters and having histories of working together in disasters contributes to the initial conditions that influence the formation of interorganizational networks. The previous section presented the established disaster management system. This section focuses on how those systems were implemented in actual disasters that involves building relationships among different types of organizations.

4.2.2.1 Experiences of Disasters

Over the past two decades, Korea has gone through various forms of disasters. Table 4 below presents the few large-scale disasters before the Gyeongju and Pohang earthquakes that occurred in 2016, 2017 respectively. The Framework Act classifies disaster into two categories - natural disasters and social accidents (Framework Act, Article 3.1). Natural disasters are disasters caused by natural phenomena while social accidents refer to damage caused by social constructs including fire, collapse, explosion, traffic accidents, medical treatment, water supply etc. Infectious diseases under the Infectious Disease Control and Prevention Act are also considered social accidents (Framework Act, Article 3.1). Based on such definitions and classification, most

disasters that resulted in a significant number of casualties were social accidents. However, the recurring problem of typhoons and heavy rainfalls is also critical, requiring close attention.

Table 4. Large Scale Disasters (Natural Disasters and Social Accidents) in Korea Past 20 Years

Year	Date	Event	Death/ Missing	Type	Location
2000	July 14	Chupungnyeong Highway serial collision	118	traffic accident	Gyeongbuk, Gimcheon-si
2001	July 14	Seoul, Gyeonggi localized heavy rainfall	59	flooding	Seoul and Gyeonggi
2002	April 15	Gimhae Chinese civil aircraft crash	128	aircraft explosion	Gyeongnam, Gimhae-si
2003	February 18	Daegu subway fire	213	facility fire	Daegu, Jung-gu
2008	January 7	Icheon refrigerated warehouse fire	40	facility fire	Gyeonggi, Icheon
2014	April 16	Sewol ferry sinking	304	ship sinking	Jeonnam, Jindo-gun
2015	May - July	Middle East Respiratory Syndrome	39	viral respiratory infection	-

Source: Yonhap News (May 29, 2016)[19], modified by the author

Sewol Ferry Disaster. Indeed, one of the most dreadful disasters within the decade was the sinking of the *Sewol* ferry. In mid-April, 2014, tragic news swept throughout Korea about the sinking of a ferry called *Sewol*. On its way to Jeju Island from Incheon carrying 447 passengers and 29 crew members, the ship was at first reported to have incurred no casualties. However, it

[19] May 29, 2016 https://www.yna.co.kr/view/AKR20160527153600060 (accessed March 17, 2022)

later turned out to be a false report. In fact, only 172 survived, more than 50% being rescued by private fishing boats and commercial vessels. With respect to disaster management, this event was comparable to the *Seohae* ferry sinking which occurred on October 10, 1993, resulting in 292 deaths. The causes of the *Sewol* disaster are extremely complex and interrelated: including illegal redesign of the ship, overloading, instability of the ship, lack of training for personnel in managing emergencies (Korean Bar Association Special Commission, 2015).

There were fierce criticisms with respect to organizational response since numerous failures or delays of communication were observed. Notably, Jindo Vessel Traffic Service Center (Jindo VTS), which controls the ships coming in and out of the coastal area was unable to control the ferry until it was reported by the Mokpo Coast Guard on 09:06, April 16. The Mokpo Coast Guard first received a report from Jeonnam Fire Service 119 Status Control Center at around 08:54 (Korean Bar Association Special Commission, 2015). There was also a disconnect in communication between the Mokpo Coast Guard and the Western Regional Coast Guard Headquarters, which was thought to have delayed relevant measures. It was 09:35 when a patrol boat of Mokpo Coast Guard arrived at the scene. The captain and the crews did not order the passengers to leave the ship but repeatedly made announcements not to move. On the ferry were 325 students from Ansan Danwon Highschool with 15 teachers who were on their way to Jeju. Because of such misleading notifications, many of the students were unable to be saved within the golden time.

Another problem was the separation of jurisdictions among the Vessel Traffic Services (VTS). Whereas fifteen VTS in the harbor were controlled by the Ministry of Oceans and Fisheries, two - Jindo and Yeosu - VTS were under the jurisdiction of the Korea Coast Guard (Korean Bar

Association Special Commission, 2015).[20] This organizational structure was thought to weaken the controlling capacity of the Jindo VTS. The lag time accumulated as the ferry emergency advanced. The first emergency call was received from a passenger at 08:52, which was then reported to Mokpo Coast Guard 2 minutes later (08:54), who reported it to Jindo VTS at 09:06. Moreover, because crucial information was not forwarded from the Mokpo Coast Guard to the upper-level organizations, the deployment of rescue personnel was delayed. Consequently, the rescue activities of the Coast Guard, Fire Agency, ROK Navy and private divers were assessed ineffective, due to the failure of relevant command and control at the scene (Park and Jang, 2018).

Middle East Respiratory Syndrome (MERS). The Middle East Respiratory Syndrome, which first appeared in the Middle East regions including Saudi Arabia, was discovered in Korea in May 2015. A total of 186 patients were infected, with 39 deaths. When the first case was reported on May 20, 2015, the Ministry of Health and Welfare argued there was no possibility of tertiary infection, which was proved wrong on June 3, 2015 when a tertiary patient was reported. Since then, the MERS Response Public-Private Joint Emergency Inspection meeting directed by President Geunhye Park was established.[21]

The Central Disease Control Headquarters (CDCHQ) is established under the Korea Disease Control and Prevention Agency when the crisis alert level becomes 'Yellow'.[22] Because the first infected case of MERS was observed on May 20, CDCHQ was established and operated on that day.[23] On May 28, it was expanded to Central MERS Management Countermeasures

[20] At the time of disaster, Korea Coast Guard was an independent external organization of the Ministry of Oceans and Fisheries.
[21] Kukmin Ilbo, June 3, 2015. 메르스 확산 비상] 朴대통령, 대응책 직접 챙기기… 늑장대응 논란 불끄기 http://news.kmib.co.kr/article/view.asp?arcid=%200009509635&code=61111111&cp=nv (accessed on March 19, 2021).
[22] There are four levels of crisis alert starting from **Blue** - **Yellow** - **Orange** - **Red** in the order of seriousness(less serious to more serious)
[23] At the time of MERS outbreak in Korea, the Korea Disaster Control and Prevention Agency was the Korea Centers for Disease Control and Prevention.

Headquarters (Central MERS HQ hereafter) under the authority of the Vice Minister of Health and Welfare. Then, the diagnosis testing of MERS in 17 local governments (City/Do) began on May 30. The 10-day gap from the first case to country-wide testing reveals that the government's action lagged, following the initial discovery. Later, on June 2, Central MERS HQ was once again expanded and led by the Minister of Health and Welfare. On June 3, the central government agencies and local governments engaged in the Government-wide MERS Countermeasures Support Headquarter led by the Minister of Public Safety and Security. The agencies involved include the: Office for Government Policy Coordination, Ministry of Health and Welfare, Ministry of Education, Ministry of Foreign Affairs, Ministry of National Defense, Ministry of the Interior, Ministry of Culture, Sports and Tourism, Ministry of Agriculture, Food and Rural Affairs, Ministry of Oceans and Fisheries, and National Policy Agency (Ministry of Health and Welfare, 2016).

Despite an increasing number of cases, the government did not disclose any information about the paths of the infected patients or the hospitals to which they were admitted. This lack of information raised concerns and fear among the citizens further generating misinformation about the disease through the internet and SNS. In terms of risk communication, the government's first regular briefing was given on June 1, 2015, the date when the first death was reported. There was a conflict between the central agencies and the local governments on managing the quarantine. For example, on June 3, Seoul Metropolitan Government, without communicating with the Ministry of Health and Welfare, announced in their briefings that the 35th patient participated in the housing union general assembly and suggested that participants of the assembly to self-quarantine. In contrast, Central MERS HQ argued that the degree of contact needs to be considered, rather than asking all participants to self-quarantine (Ministry of Health and Welfare, 2016). After a series of meetings of the public-private joint Task Force and with the local governments, the Central MERS

HQ eventually disclosed the list of hospitals within the path of infected patients from June 4 onwards (Ministry of Health and Welfare, 2016). The information publicized through the government briefings were made accessible on MERS portal.[24]

4.2.2.2 The History of Disaster Management Organizations

In addition to experiencing actual disasters together, the history of disaster management organizations - in what context were they created; what tasks did they perform; with whom did they work; how were they rearranged - provides an overview of actions taken in forming the initial conditions of the environment. Thus, this section addresses the history of central government organizations dealing with disaster management.[25]

First, the Civil Defense Headquarters was established within the Ministry of Home Affairs in 1975, which became the Civil Defense Disaster Control Headquarter in 1995, maintaining authority over civil defense, disaster prevention, and firefighting. Later in 1998, the Ministry of Home Affairs and the Ministry of Government were integrated into the Ministry of Interior. In 2004, with the creation of the National Emergency Management Agency (NEMA), the civil defense and disaster functions were incorporated into the new organization. The NEMA was maintained until 2014 when the functions were transferred to the Ministry of Public Safety and Security.

In 2008, the Ministry of the Interior and Safety was established, consolidating the functions of the Ministry of Interior, Civil Service Commission, Emergency Planning Commission, and

[24] The MERS portal is no longer accessible.
[25] This chapter refers from: 정부조직관리정보시스템 (행정안전부)
https://www.org.go.kr/orgnzt/chnge/viewAdmnstMach.do#;
행정안전부 국가기록원 기록물 생산기관 변천 정보
https://theme.archives.go.kr/next/organ/organBasicInfo.do?code=OG0002944

partial functions of the Ministry of Information and Communication. The organization was renamed - from the Ministry of the Interior and Safety to the Ministry of Security and Public Administration (MSPA) - in 2013 intentionally placing security (safety) ahead of administration. However, the failure of proper response in the *Sewol* ferry disaster a year later, proved it to be a mere symbolic action.

Taking responsibility for failure in the *Sewol* ferry disaster, the government created a brand-new organization called the Ministry of Public Safety and Security (MPSS) in November 2014, which absorbed safety functions from the MSPA, VTS from the Ministry of Oceans and Fisheries (MOF), NEMA, and the Korea Coast Guard (KCG). The biggest change was the consolidation of NEMA and KCG naming them Central Fire Service and KCG respectively.[26] The Central Fire Service, a land based disaster response organization, was dichotomized into national and local organizations which were criticized for lacking control over local operations.[27] This division raised an issue because the Central Fire Service was a central level organization whereas local Fire Departments were controlled by local jurisdictions.[28] The Fire Service has been in the Ministry of Home Affairs (1948-1998), Ministry of Interior (1998-2004), and became an independent agency as the NEMA (2004-2014) before it was incorporated into the MPSS in 2014. In 2017, it became an independent agency - National Fire Agency (2017 onward).

The KCG has been within the Ministry of Home Affairs (1953-1955, 1962-1991), Maritime Affairs Administration (1955-1962), National Police Agency (1991-1996), Ministry of

[26] Though its English name remained the same, the Korean name for the KCG was changed from 해양경찰청 to 해양경비안전본부. When translated literally, the new name of the division under MPSS reads 'Coast Guard Safety Headquarter'.
[27] Financial News, May 27, 2014. 국가안전처, 소방조직 반쪽만 편입… '재난 사령탑' 제기능 할까, https://news.naver.com/main/read.nhn?mode=LSD&mid=sec&sid1=100&oid=014&aid=0003169172 (accessed Mar 22, 2021)
[28] The local fire departments were incorporated into the National Fire Agency on April 1, 2020.

Oceans and Fisheries (1996-2008; 2013-2014; 2017 onwards), Ministry of Land, Transport, and Maritime Affairs (2008-2013), and Ministry of Public Safety and Security (2014-2017). In the *Sewol* ferry disaster, the KCG was fiercely blamed for its inability to take prompt action, was disestablished, and incorporated into the MPSS.

The Ministry of Public Safety and Security (MPSS) was the major control center in the Gyeongju earthquake in 2016. It was approximately two years since the MPSS had been established at the time of the earthquake. The MPSS had to work intimately with the Korea Meteorological Administration (KMA) which had the capacity to detect the seismic waves and the responsibility to send Earthquake Early Warning to the MPSS. However, the emergency alert through the CBS was sent 9 minutes after the earthquake, which was thought to be far behind the critical time.[29] Before sending the CBS, the KMA first figured out the magnitude of the earthquake and then the MPSS analyzed the impacted area. Figure 12 below illustrates the flow of the CBS system during the Gyeongju earthquake. Acknowledging inefficiency of the process, MPSS and KMA made an agreement to transfer the tasks of CBS to KMS in November 2016 (MPSS, 2017).

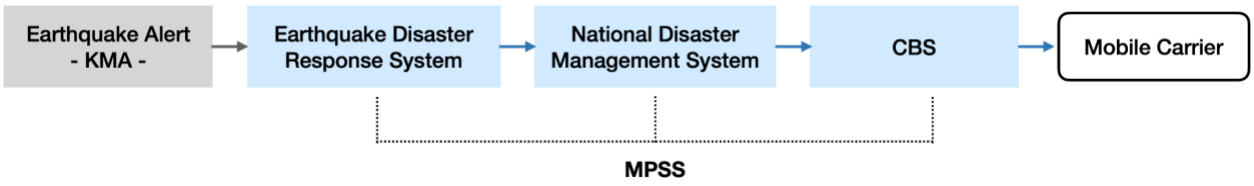


Figure 12. The Process of CBS System before November, 2016

Source: Ministry of Public Safety and Security (2017)

[29]Hankyung, September 13, 2016, "경주 지진에 무너진 건 국민안전처 홈페이지뿐" https://www.hankyung.com/society/article/201609139345H (accessed on March 22, 2021).

In between the two earthquakes, the former President Geunhye Park was impeached. With the President Jaein Moon's Administration, the MPSS was integrated with the Ministry of Interior (MOI) creating the Ministry of the Interior and Safety (MIS). Thus, in the Pohang earthquake MIS served as the control center for disaster management. As the task of sending emergency alerts of earthquakes through CBS was handed over to KMA, the alert message was sent within 23 seconds. This was made possible through an integrated server within the MIS system.

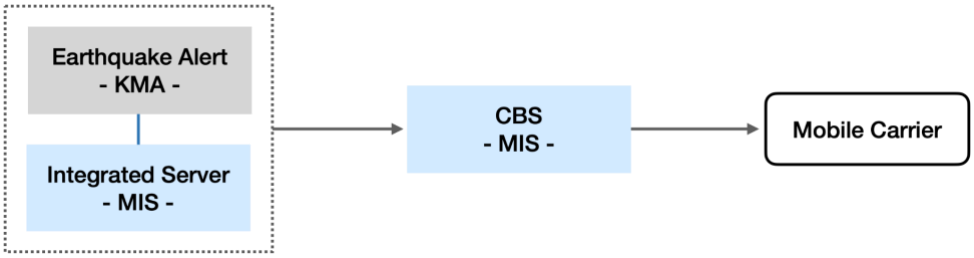


Figure 13. The Process of CBS System after November 2016

Source: Ministry of the Interior and Safety (2018)

4.3 Summary of the Environments as Starting Conditions

The starting conditions identified in the earlier sections described the environment in which response operations to the two earthquakes were undertaken. The disaster management system, which formed the basis for organizational networks, pulled the relevant organizations together in disaster operations, according to their functions. When a disaster reaches a certain level as stated by law, emergent organizations such as CDSCHQ, CDMHQ, and CERCG are constituted. Although these entities are non-standing organizations, the resources they share, information and knowledge they exchange cannot be separated from their relationships developed in normal

operations. In addition to defining the organizational structure, the institutions and policies formally enact how the collectives of organizations should work with one another. This also implies that imbalance exists among the organizations associated with the resources, information, knowledge, and power. For instance, in conducting the joint inspection, the head of CDSCHQ may request other agencies to dispatch personnel (Framework Act, Article 32(2)). In such cases, the CDSCHQ - led by the MPSS in Gyeongju, MIS in the Pohang earthquake - has power over other disaster management agencies while those being requested for resources have the capacity to support them.

Whereas the disaster management system and institutions demonstrate the static picture of how the system should operate, the history of working together in the past provides a more dynamic view of how the systems have operated in practice. By experiencing disasters together, organizations interact through diverse channels. Two focal events that led to creating a new disaster control center - the MPSS - and evaluation of its capacity, were the *Sewol* ferry disaster and MERS outbreak. Because problems in communication were exposed in dealing with the ferry disaster, the government decided to integrate safety related functions into one organization. However, faced with a different type of disaster that occurred a year after the birth of MPSS, the status of the newly established organization was assessed to be ambiguous (Park and Baek, 2016). In fact, in MERS, the Central Disease Control Headquarter and later the Central MERS Management Countermeasures Headquarter were installed under the authority of the Ministry of Health and Welfare. Two weeks after the detection of the first case, the MPSS established the Government-wide MERS Countermeasures Support Headquarter which was intended to support the MERS CDCHQ. But the role of the MPSS was assessed to be insignificant despite the stated goal of the MPSS to enhance the efficiency of disaster management through unified control. The

complexity of the management system increased even more after the Blue House (the President) formed Public-Private Joint Response Task Force roles, baffling the authorities and functions of the related organizations.[30]

The narratives of relationships in the longer time frame were seen through the history of the major disaster management organizations. The disaster-related functions were sometimes incorporated under the organizations dealing with internal affairs (as were the Ministry of Home Affairs, Ministry of the Interior and Safety, and Ministry of Security and Public Administration); at other times, they were instituted independently from other functions (as were the National Emergency Management Agency and Ministry of Public Safety and Security). Such an organizational history lays out the links between the organizations, not only those that currently exist but those that existed before. This finding implies that there could be differences in networks of organizations in the responses to the Gyeongju earthquake and Pohang earthquake due to the history entailed in formation of the two distinct organizations - the Ministry of Public Safety and Security versus the Ministry of the Interior and Safety. Figure 14 below shows the passage of organizational changes combined with corresponding power, resources, and information/knowledge that different organizations command. This is not an exhaustive profile encompassing changes of all disaster management agencies but rather an account of key organizations that have gone through significant changes.

Although the disaster management system of Korea is structured so that functions of central agencies are connected to their local counterparts and local governments, it is still highly centralized towards the central government. A time gap was observed between activation of the Central Disease Control Headquarter and implementation of diagnosis at the local level during the

[30] Chosun Ilbo, June 9, 2015 '메르스 대책본부' 3 개 동시에 가동 … 컨트롤 타워 아직도 '혼선' https://www.chosun.com/site/data/html_dir/2015/06/09/2015060900263.html (accessed March 24, 2021)

MERS crisis. Moreover, there was conflict between the central and local government operations due to disconnected communication. Such examples reveal the weaknesses of a highly centralized system which might be vulnerable to disaster events that require rapid response at the local level. Therefore, it is important to investigate how this highly centralized system could enhance effectiveness by developing ties to the local actors.

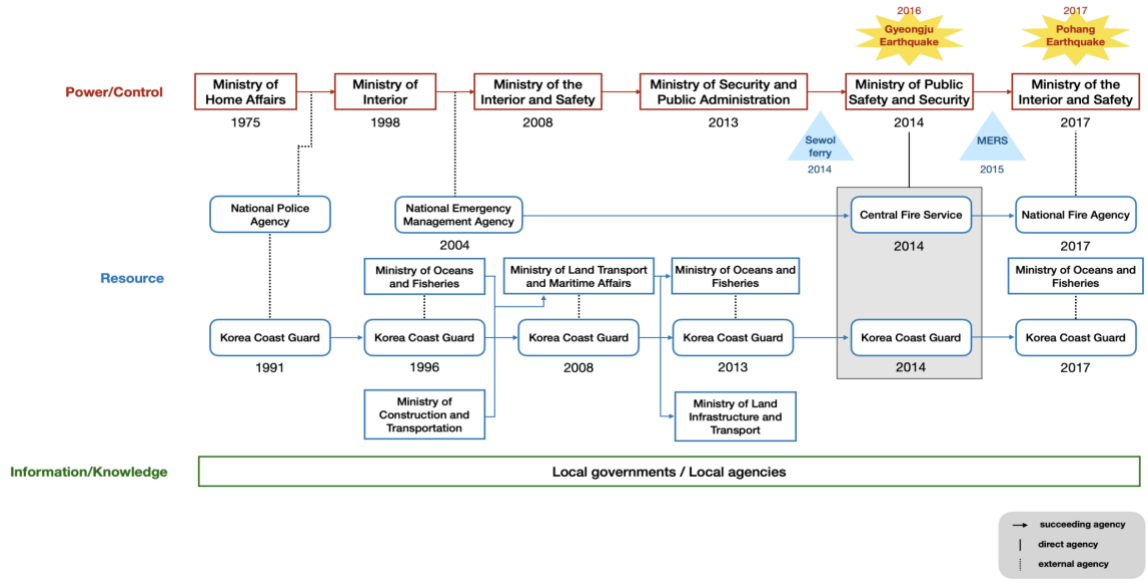


Figure 14. Organizational Changes in the Key Agencies of Disaster Management System

5.0 The Comparison of Inter-Organizational Networks in Response to the Gyeongju and Pohang Earthquakes

Based on the backgrounds of the two earthquake cases and starting conditions, the interorganizational networks in response to the respective earthquakes will be explored. First, the descriptive properties of networks at different levels enable specifying various aspects of the network. Then, through comparison of the two cases, the similarities and differences of such properties will be addressed. As discussed in the previous chapter, reorganization of the major disaster management agencies that occurred in the time between the two cases is assumed to have influenced the response networks. This means that structural change in a single agency could have impacted other individual organizations, groups of organizations, and ultimately, the network as a whole. Although such chains of influence can best be observed through continuous analysis, it is extremely difficult to determine which measurement is suitable for such an analysis and, even more difficult, to ensure its consistency throughout the time span. Rather than simplifying the complexity, this research adopted an alternative way of comparing characteristics of two networks in discrete points in time while accepting the dynamics of the environment. Multiple measures at different levels were employed to analyze the network. This chapter applies the theoretical framework of complex adaptive system to the Korean disaster management system, followed by results of the analysis. Finally, based on the results, implications will be derived with respect to the relationship between reorganization and interorganizational networks.

5.1 Disaster Management System as a Complex Adaptive System

A disaster management system is a complex adaptive system in which individual organizations themselves are complex adaptive systems. This characterization rightly conforms to the concept of the strategic action fields in which a bigger field nests smaller fields implying interdependencies among them (Fligstein and McAdam, 2012). Based on the framework of complex adaptive systems, the disaster management system of Korea could be broken down into multiple elements to help conduct a refined comparison of the networks.

5.1.1 Exogenous Shock: Reorganization

First, an exogenous shock that destabilized the strategic action fields in this research is the Korean government's central level reorganization. Such a shock emanates from changes in fields on which a specific field relies. Initiated by the reorganization of major agencies in the disaster management system, subsequent changes are likely to ensue affecting the overall network arrangements. The biggest change between the two earthquakes - Gyeongju earthquake and Pohang earthquake - was the reorganization of the Ministry of Public Safety and Security (MPSS). The detailed history was delineated in Chapter 4. To briefly reiterate, MPSS was created after the *Sewol* ferry disaster incorporating safety-related functions that had been distributed throughout different agencies. Shortly after President Jaein Moon took office in May 2017, the MPSS once again disintegrated, and the Vice-Minister level disaster and safety management offices were formed within the Ministry of the Interior and Safety (MIS) that was active in the Pohang earthquake. Since the MPSS and MIS both served as the controlling agency in disasters, it is assumed that the reorganization had considerable influence across the field.

5.1.2 Agents: Governmental Agencies, and Local Governments

The basic unit within complex adaptive systems is an agent. Agents use building blocks to develop internal models, based on which decisions are made (Holland, 1992). The building blocks could be recombined to create a different set of rules (Holland, 1992). Government agencies, and local governments are agents that have individual internal models. At the same time, they develop relationships with other agents and create rules that govern the field (Fligstein and McAdam, 2012). Unless explicitly stated by the agents, it is difficult to determine how the agents' internal models operate. Thus, I take an indirect path of understanding their internal models by investigating the results, i.e. the consequences of applying their internal models, identified through their patterns of interactions. By employing various measures of network analysis, the major agents, interchangeable with actors and nodes, are discovered.

5.1.3 Niche: Sub-Network Communities of Government Agencies and Local Governments

While agents' patterns of interactions are focused on individual node levels, the patterns that remain throughout and beyond the actions of the agents characterize an existence of a niche (Holland, 2012). In terms of fields, each agent has its own fields which tend to be affected by other agents' fields. When agents regularly build relationships, a community is formed within the network. The organizations in the disaster management system also create communities that have stronger relationships with certain organizations. This would be observed by formation of a community (modularity) and a clique. The rules that govern the niches may not be straightforward like the internal models of the agents. Thus, interpretations of the results need to be made carefully with the help of laws, policies, institutions, and history of relationships between the actors. Another

critical factor to consider is the varying degrees of dependencies. Members of a community might have different scales of interactions influencing the extent to which they depend on one another. The weight of interactions, i.e. the thickness of ties between the two nodes, indicates such dependencies. Considering the dependencies among agents, the formation of communities will be compared before and after the reorganization.

5.1.4 Environment: Dynamics of Fields in Disaster Management System

Since agents form an environment for others within a complex adaptive system (Holland, 2012), reorganization by an agent entails changes in the environment for others. Once an exogenous shock triggers change, subsequent changes occur, inducing dynamics among the fields. The initial conditions of the disaster management system at the onset of a dynamic event are investigated to see whether these conditions maintain their leverage in the network. Particularly the change in environments will be analyzed with respect to having common experiences in disaster events and in the history of organizational changes within the disaster management system.

5.1.5 Adaptation and Outcome: Evolution of Networks and Emergence of a New System

Agents and niches constantly adjust themselves to the environment by rearranging the building blocks that compose their internal models and rules. This process is referred to as adaptation in a complex adaptive system, featuring the agents' capacity to learn through experience. An outcome is the result of such adaptation and could be monitored through emergence of a new system (Mitleton-Kelly, 2003). In this chapter, static pictures showing the results of adaptation will be analyzed as the first step. Although the results in this chapter capture the networks at the

time of the earthquake events rather than the evolution of networks over time, the comparative approach provides an understanding of how the disaster management system has evolved as shown at discrete points in time. In addition, by employing various measures to analyzing the network, the effects of exogenous shock - the reorganization - are clarified.

Figure 15 below illustrates the framework of the complex adaptive system applied to this chapter to capture the similarities and differences of the disaster management system operated in the Gyeongju and Pohang earthquakes. First, the disaster management system of the Gyeongju earthquake is considered as a set of interorganizational networks. Then, the reorganization is assumed to affect the system generating specific outcomes, which in turn affects the disaster management system in the Pohang earthquake. The results of analyses are compared at the network level, node level, and finally, the sub-network group level.

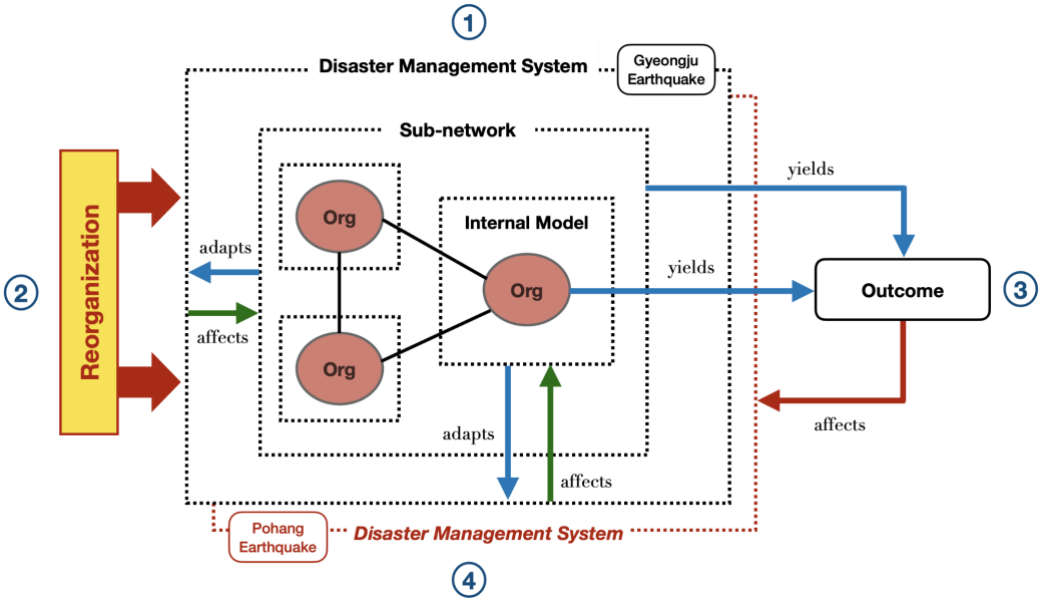


Figure 15. Application of Complex Adaptive System Framework

5.2 The Results

5.2.1 Network Level Comparison

Based on the government reports published during the respective earthquakes, network level results of the interorganizational interactions are laid out in table 5. Network size, notifying how big is the network, is reported both by the number of nodes and diameter. The number of nodes was slightly higher in the Gyeongju earthquake - Gyeongju having 32 nodes; Pohang 30 nodes. The diameter was 2 in Gyeongju whereas it was 4 in Pohang. This means that out of all the shortest paths (edges, ties) linking any two nodes the maximum value was 2 and 4 respectively. Thus, the distance of two nodes farthest apart was larger in Pohang, noting that though the number of nodes were slightly higher in the Gyeongju earthquake, the distance reaching from one end to the other was farther in Pohang.

The density, measured by how many links existed out of all the possible links, was 0.124 in the Gyeongju earthquake and 0.163 in the Pohang earthquake. Hence, the participating organizations had more ties to each other in Pohang than in the Gyeongju case. In addition to the density, centralization measures the cohesion of the network but from a different perspective. Degree centralization indicates how much the network is centralized to the node with the highest degree centrality (Wasserman and Faust, 1994). The result shows that the organizations were more integrated around a focal point in the Gyeongju earthquake with degree centralization of 61.11%, whereas the Pohang earthquake had 45.32%. Similarly, the betweenness centralization value, the extent of cohesion around the node that is the most influential mediator (Wasserman and Faust, 1994), was higher in Gyeongju (31.27%) compared to Pohang (22.62%).

Table 5. Comparison of Network Level Properties

Network Properties		Gyeongju earthquake	Pohang earthquake
Size	No. of Nodes	32	30
	Network Diameter	2	4
Density		0.124	0.163
Degree Centralization		61.11%	45.32%
Betweenness Centralization		31.27%	22.62%

The network graphs in figure 16 visualize how the whole network is structured. As seen from the previous results, the number of nodes is roughly the same, but the attributes of the nodes - the levels of government/agencies - are more diverse in the case of Gyeongju. The width of the links, or edges, displays the weight of interactions, that is, the frequency of interactions between the two nodes. Thus, the thicker the link, the greater the number of interactions between the organizations. In the Gyeongju and Pohang earthquakes alike, the MPSS and MIS as control centers, are the nodes that have more frequent interactions with connected nodes. Viewed from the network graph, the MPSS had the closest relations to the Gyeongju City (GJC) and Ulju County (UJC). The MIS in Pohang earthquake frequently interacted with MOE, MOHW, and Pohang City (PC).

There are 11 isolated nodes in the Gyeongju earthquake while 7 isolated nodes are present in the Pohang case. The central level agencies isolated in both cases were OPC, FSC, MOLEG. There were interesting results with regards to isolated nodes in each case. While MOF, KFS, and MOEN were isolated in the Gyeongju earthquake, they were engaged in the network in the Pohang case. The KFS, in particular, was linked to Pohang City (PC) and North Gyeongsang Province (NGP), where the epicenter was located in the Pohang earthquake. Inversely, MAFRA, MOTIE,

and KCC were the isolated nodes in the Pohang earthquake but were in close contact with other central agencies in the Gyeongju earthquake.

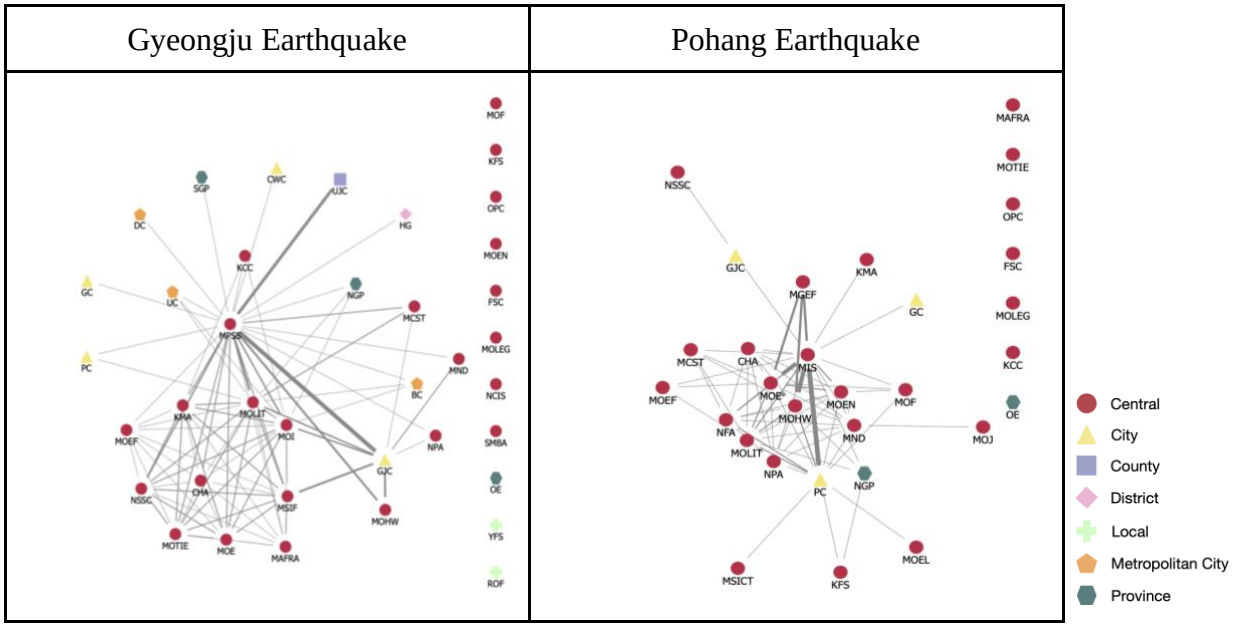


Figure 16. Whole Network Graphs of Gyeongju and Pohang Earthquakes

5.2.2 Node Level Comparison

5.2.2.1 Degree Centrality - Nodes with Many Ties

At the node level, centrality measures and indicators of structural holes were employed. The degree centrality, conveying how connected a node is to other nodes, had a mean value of 0.124 in Gyeongju and 0.163 in Pohang. One might have noticed that the mean value of degree centrality in the table 6 below equals density of the whole network. This is a corollary of a mathematical formula connecting the two concepts. That is, $Density = \frac{m}{\frac{n(n-1)}{2}}$, where m is the number of ties and n is the number of nodes, which could be rearranged as $\frac{2m}{n(n-1)}$. Then again when broken down into $\frac{1}{n} * \frac{2m}{n-1}$, this equals the mean of degree centrality since $\frac{2m}{n-1}$ is the

definition of sum of all degree centrality values. The mean of degree centrality was higher in the Pohang network implying more nodes with high degree centrality existed in the Pohang earthquake. But this should be distinguished with the degree centralization which denotes the extent of cohesion around the focal points which was higher in the network of the Gyeongju earthquake. This also is a consequence of the formula of centralization specified in Chapter 3.

In both cases, the minimum value of degree centrality was zero, since there were nodes without any connection, the isolated nodes. The maximum value of degree centrality was 0.703 in Gyeongju and 0.586 in Pohang, which is quite far from the mean value. If graphs were to be drawn on degree centrality both cases would have a right skewed graph.

Table 6. Distribution of Degree Centrality Scores in Gyeongju and Pohang Earthquakes

Measures	Degree Centrality	
	Gyeongju	Pohang
Mean	0.124	0.163
Std. Dev.	0.158	0.173
Min.	0	0
Max	0.703	0.586

A more detailed account could be made by analyzing the network graphs of the two cases. Figure 17 captures the network graph based on degree centrality. As in the whole network graph, the thickness of edges denote the frequencies of interactions between the nodes (i.e. weight). The size of the nodes signals the relative importance of the organizations in terms of connectedness to other nodes, i.e. the degree centrality. This is essentially the same network illustration as addressed in the network level structure but highlighting the degree centrality of individual nodes with

varying sizes. From the network graph we can observe that whereas the central agencies are connected to one another creating a complex web, the local agencies and governments are less connected to various organizations. In the Gyeongju case, many of the local organizations are only connected to others through the MPSS. Though a smaller number of local actors appear in the Pohang earthquake, the degree centrality of the local actors in the Pohang earthquake is higher than that of Gyeongju. This is depicted in the different sizes of the nodes in the network graph.

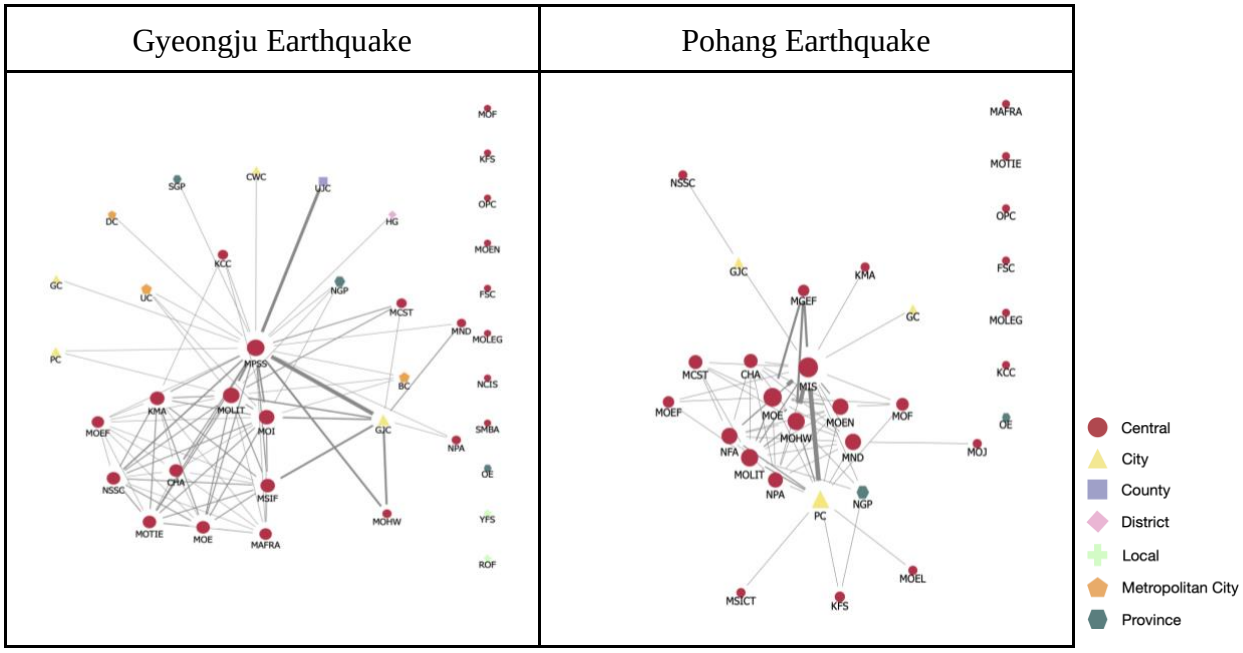


Figure 17. Network Graphs Based on Degree Centrality

Another way to compare the degree centrality value is to use the concentric map shown below in figure 18. The concentric map places the node with the highest value at the center and then draws circles in increasing order of radius around the center. The closer to the center the higher the centrality value. Also, the nodes within a single circle have approximately the same centrality values. Hence, a concentric map enables better comparison of relative values of two or more nodes. Seen from the concentric map of the Gyeongju case and Pohang case, the MPSS does

not have many organizations closer to the center where it is located. Again this corresponds to the high degree centralization value of the Gyeongju case where the role of the MPSS becomes more central in connectedness to other nodes. Nearer to the center and the MPSS, are central agencies such as MOLIT, MOI, MSIF. On the other hand, the concentric map of the Pohang case reveals that more of the nodes are populated around the center. This implies that while the MIS maintains the focal point many other actors also play key roles in terms of connectedness. Some of the key actors in the Pohang earthquake in terms of degree centrality include MOLIT, MOE, MOHW, NPA, NFA, MND, and MOEN. Noteworthy is that local governments of the epicenter came closer to the center in the Pohang earthquake, especially the city level government that was directly affected by the earthquake, the PC.

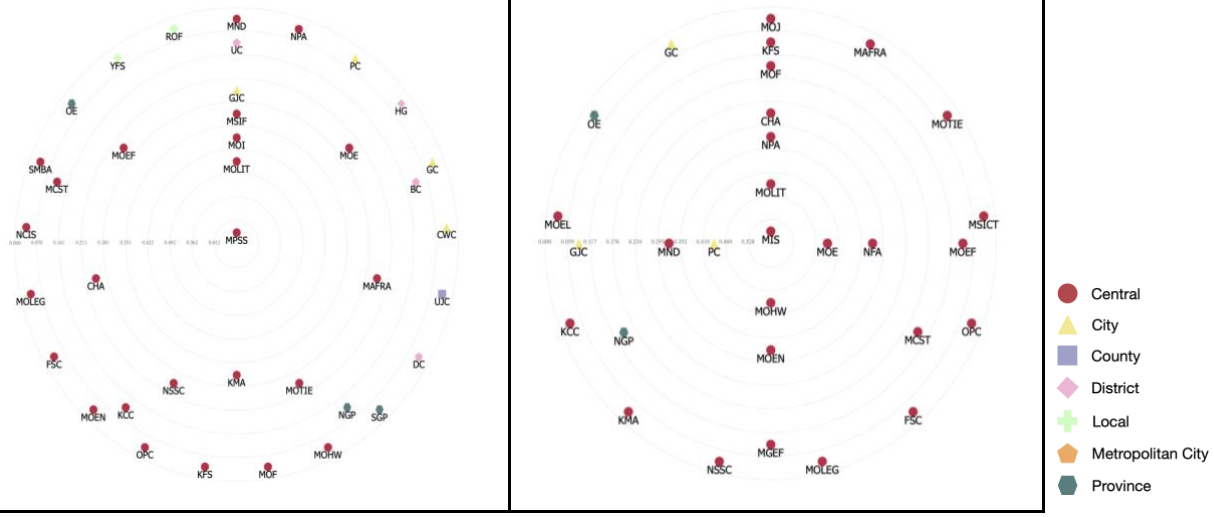
Gyeongju Earthquake	Pohang Earthquake
	

Figure 18. Concentric Maps Based on Degree Centrality

5.2.2.2 Eigenvector Centrality - Nodes Tied to Influential Nodes

Degree centrality measures the connectedness of the network, but it does not provide an idea about how much impact it has by being connected to other important actors. For instance,

even though a node has many ties, it may only be connected to nodes of marginal importance within the network. Thus, it is critical to consider the degree of connectedness to other key nodes. Eigenvector centrality measures such features by assigning eigenvalue of 1 to the top node and subsequently assigning scores proportional to their closeness to the top node. Table 7 shows the distribution of eigenvector centrality scores in the Gyeongju and Pohang cases. The mean value of eigenvector centrality was 0.096 and 0.1 in the Gyeongju and Pohang earthquakes respectively. The standard deviation was a little higher in the Pohang earthquake having more nodes spread out from the mean.

Table 7. Distribution of Eigenvector Centrality in Gyeongju and Pohang Earthquakes

Measures	Eigenvector Centrality	
	Gyeongju	Pohang
Mean	0.096	0.1
Std. Dev.	0.131	0.153
Min.	0	0
Max	0.539	0.556

The size of nodes in the network graph in figure 19 now represents each node's relative importance within the network in terms of being connected to other nodes with high influence (eigenvalue). The overall network graph looks very similar to the network graph highlighting the degree centrality. However, the concentric map captures a few differences (figure 20). First, in the Gyeongju case, the MOLIT, which had relatively higher degree centrality, was farther away from the center in eigenvector centrality. This observation implies that even though the MOLIT had many ties, the agency was not influential since they were connected to less dominant nodes. In the

Pohang earthquake, the local governments including PC moved farther away from the center compared to the degree centrality. This finding implies that while the local government had relatively high connectedness, it was less likely to have impact on others because it was not linked to highly influential nodes. Moreover, central level agencies such as MOLIT, MND, and MOEN also moved farther away from the center in the eigenvector concentric map compared to the degree centrality.

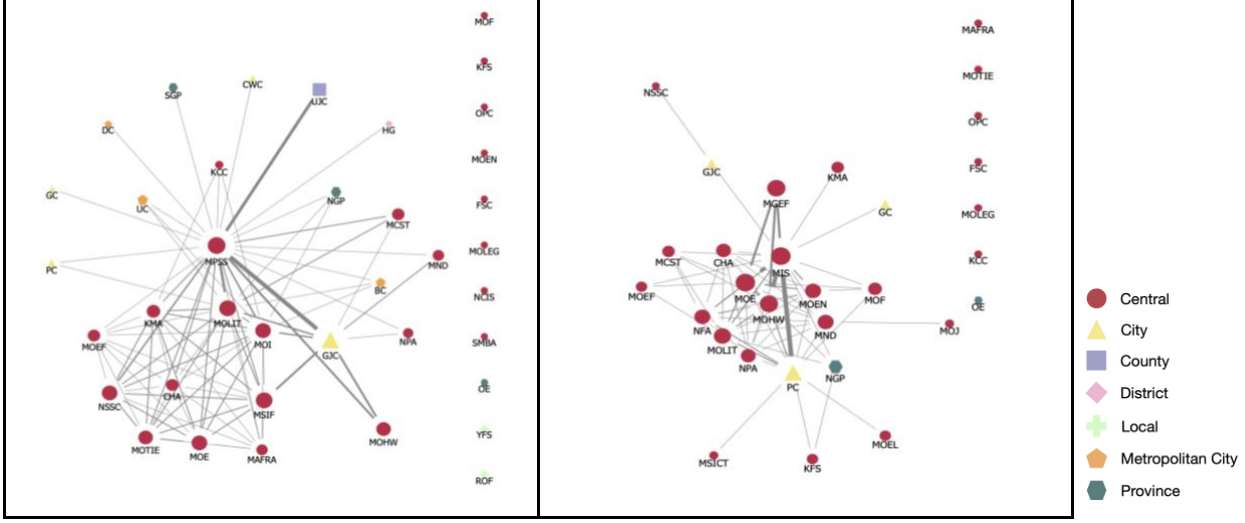
Gyeongju Earthquake	Pohang Earthquake
	

Figure 19. Network Graphs Based on Eigenvector Centrality

Gyeongju Earthquake	Pohang Earthquake

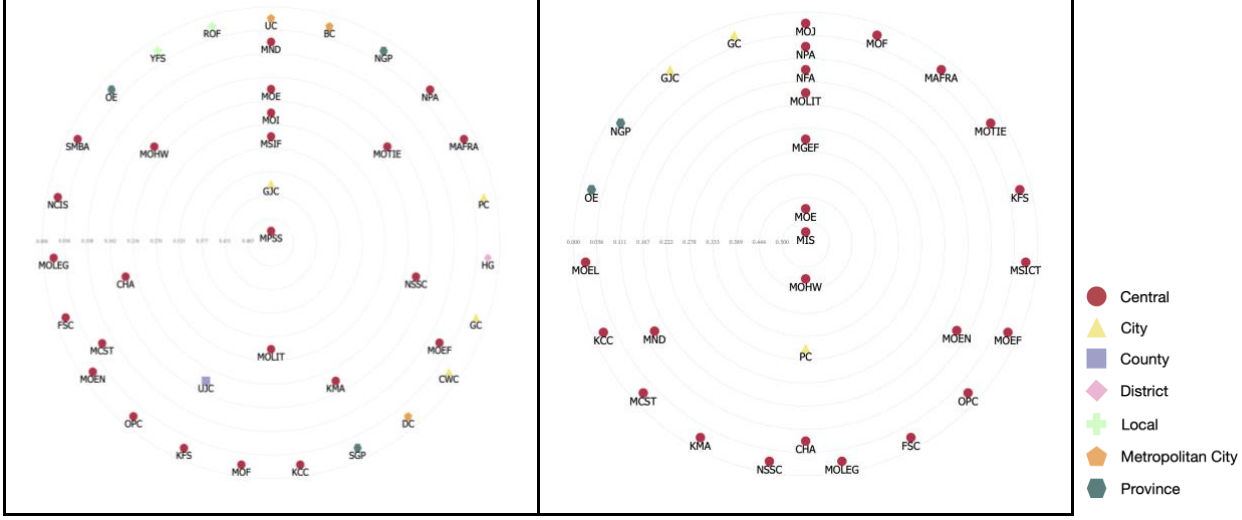


Figure 20. Concentric Maps Based on Eigenvector Centrality

Eigenvector centrality of the local governments where the epicenters were located also showed distinction in the Gyeongju and Pohang earthquakes. In the Gyeongju earthquake the GJC had lower eigenvector centrality (0.094) compared to that of PC (0.295) in the Pohang earthquake (see table 9). This finding suggests that Gyeongju City at the local level was less likely to be tied to the MPSS in disaster response operations, whereas Pohang City was more likely to be connected to the MIS.

With regard to the central level agencies, some discrepancies were observed. MOE and MOHW, which had eigenvector centrality of 0.271 and 0.199 in the Gyeongju case, had relatively higher eigenvector centrality in the Pohang case with 0.447 and 0.446 respectively. Such results infer these organizations might have had specific roles in the Pohang earthquake. Conversely, agencies like the KMA had higher eigenvector centrality value in the Gyeongju earthquake(0.422) relative to the Pohang case(0.019) (see table 9). Some of the central level agencies were central in terms of being connected to other prominent nodes in one case but not in the other. The MGEF

had quite high eigenvector centrality of 0.299 in the Pohang earthquake but did not appear in the network of Gyeongju earthquake. On the other hand, MSIF showed eigenvector centrality of 0.194 in the Gyeongju case but the eigenvector centrality of its reorganized successor MSICT was only 0.003 in the Pohang case.

5.2.2.3 Betweenness Centrality - Nodes Serving as Bridges

While degree centrality and eigenvector centrality measure the extent to which the nodes are connected to other nodes or other influential nodes, betweenness centrality measures whether it is located in between other two nodes' shortest path. As seen in table 8 below, the mean value of betweenness centrality in both Gyeongju and Pohang is 0.01 in Gyeongju and 0.02 in Pohang. This is a rather low value compared to degree and eigenvector centrality. We may assume many of the nodes are directly linked rather than going through other mediating nodes.

Table 8. Distribution of Betweenness Centrality in Gyeongju and Pohang Earthquakes

Measures	Betweenness Centrality	
	Gyeongju	Pohang
Mean	0.01	0.02
Std. Dev.	0.051	0.049
Min.	0	0
Max	0.315	0.238

Apparently, the MPSS in the Gyeongju earthquake and the MIS in the Pohang earthquake showed the maximum value of betweenness centrality in each case. As noted in the concentric map (figure 22), there are almost no organizations near the center, an observation that more

apparent in the Gyeongju case. In other words, in the Gyeongju earthquake, the MPSS served as the major bridge without which other nodes could be connected in the shortest possible path. In the Pohang earthquake, following the MIS, the city level governments Pohang City (PC) and Gyeongju City (GJC) had relatively high betweenness centrality. In general, the Pohang earthquake, the local governments seemed to have more communicative power by linking other participating organizations.

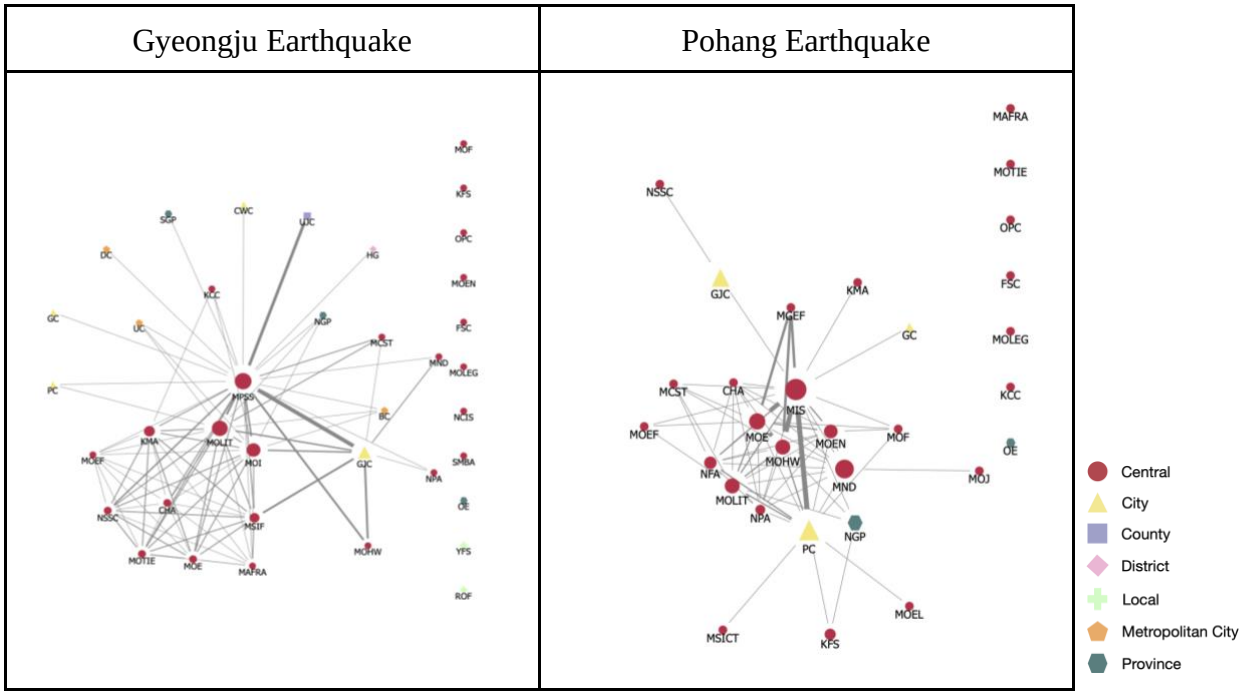


Figure 21. Network Graphs Based on Betweenness Centrality

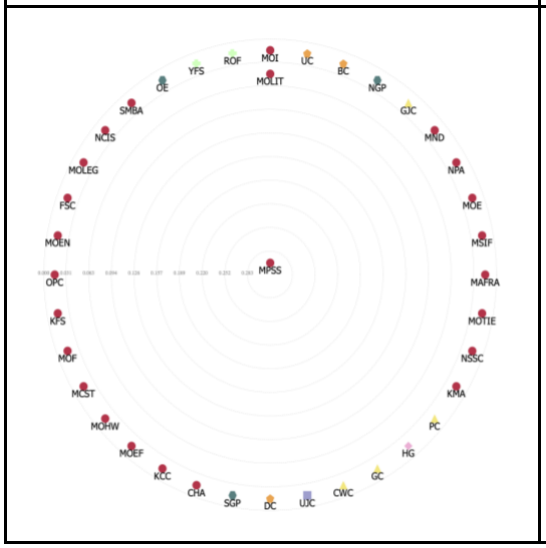
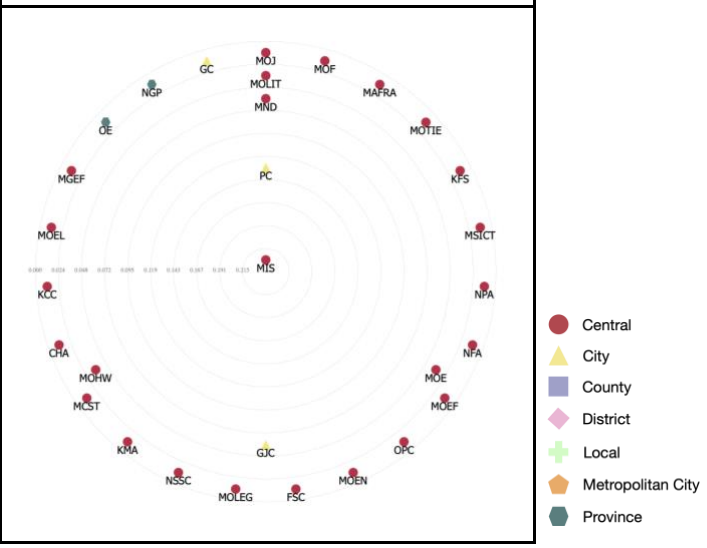
Gyeongju Earthquake	Pohang Earthquake
	

Figure 22. Concentric Maps Based on Betweenness Centrality

With respect to the central level agencies, MND, MOHW, and MOE also served more actively as bridges between others in the Pohang earthquake compared to the Gyeongju case. Still, this finding is relative in the Gyeongju case and does not actually mean they are the major bridges between other organizations. In fact, the betweenness centrality values in the Pohang earthquake indicated that the MND (0.053), MOE (0.034), and MOHW (0.026) are far from the maximum value of 0.238 (see table 9).

Table 9. Comparison of Centrality Values

	Degree Centrality				Betweenness Centrality				Eigenvector Centrality			
	Gyeongju		Pohang		Gyeongju		Pohang		Gyeongju		Pohang	
	Org	**Value**	**Org**	**Value**	**Org**	**Value**	**Org**	**Value**	**Org**	**Value**	**Org**	**Value**
1	MPSS	0.703	MIS	0.586	MPSS	0.315	MIS	0.238	MPSS	0.539	MIS	0.556
2	MOLIT	0.432	MOE	0.448	MOLIT	0.037	PC	0.137	KMA	0.422	MOE	0.447
3	MOI	0.405	PC	0.414	MOI	0.025	MND	0.053	MOLIT	0.310	MOHW	0.446
4	KMA	0.297	MOLIT	0.414	KMA	0.012	GJC	0.052	MOE	0.271	MGEF	0.299
5	MSIF	0.297	MOHW	0.414	MSIF	0.004	MOE	0.034	MOI	0.263	PC	0.295
6	MOE	0.270	MND	0.345	MOE	0.003	MOLIT	0.026	CHA	0.215	MOLIT	0.204
7	MOTIE	0.270	MOEN	0.345	-	-	MOHW	0.026	MOTIE	0.205	NFA	0.143
8	NSSC	0.270	NFA	0.345	-	-	NGP	0.012	MOHW	0.199	MOEN	0.124
9	CHA	0.270	NPA	0.310	-	-	MOEN	0.006	NSSC	0.199	MND	0.114
10	MAFRA	0.243	CHA	0.276	-	-	NFA	0.005	MSIF	0.194	NPA	0.109
11	MOEF	0.243	MCST	0.172	-	-	KFS	0.002	UJC	0.172	CHA	0.098
12	GJC	0.216	NGP	0.138	-	-	NPA	0.001	MAFRA	0.165	NGP	0.042
13	UC	0.081	MOF	0.138	-	-	-	-	GJC	0.094	MOF	0.029
14	BC	0.081	MOEF	0.103	-	-	-	-	MCST	0.090	MCST	0.021

Table 9. Comparison of Centrality Values (continued)

15	NGP	0.081	MGEF	0.103	-	-	-	-	MND	0.081	KMA	0.019
16	KCC	0.081	GJC	0.069	-	-	-	-	MOEF	0.045	MOEF	0.014
17	MCST	0.081	KFS	0.069	-	-	-	-	UC	0.043	KFS	0.011
18	MND	0.054	MOJ	0.034	-	-	-	-	NGP	0.029	MOEL	0.007
19	NPA	0.054	MSICT	0.034	-	-	-	-	NPA	0.027	GJC	0.006
20	PC	0.054	NSSC	0.034	-	-	-	-	BC	0.022	GC	0.006
21	MOHW	0.054	KMA	0.034	-	-	-	-	SGP	0.014	MSICT	0.003
22	HG	0.027	MOEL	0.034	-	-	-	-	KCC	0.013	MOJ	0.001
23	GC	0.027	GC	0.034	-	-	-	-	PC	0.011	-	-
24	CWC	0.027	-	-	-	-	-	-	HG	0.007	-	-
25	UJC	0.027	-	-	-	-	-	-	GC	0.007	-	-
26	DC	0.027	-	-	-	-	-	-	CWC	0.007	-	-
27	SGP	0.027	-	-	-	-	-	-	DC	0.007	-	-

Acronyms	
• BC: Busan City • CHA: Cultural Heritage Administration • CWC: Changwon City • DC: Daegu City • GC: Gumi City • GJC: Gyeongju City • HG: Haeundae Gu • KCC: Korea Communications Commission • KFS: Korea Forest Service • KMA: Korea Meteorological Administration • MAFRA: Ministry of Agriculture, Food and Rural Affairs • MCST: Ministry of Culture, Sports and Tourism • MGEF: Ministry of Gender Equality and Family • MIS: Ministry of Interior and Safety • MND: Ministry of National Defense • MOE: Ministry of Education • MOEF: Ministry of Economy and Finance • MOEL: Ministry of Employment and Labor • MOEN: Ministry of Environment	• MOF: Ministry of Oceans and Fisheries • MOHW: Ministry of Health and Welfare • MOI: Ministry of Interior • MOJ: Ministry of Justice • MOLIT: Ministry of Land, Infrastructure, and Transport • MOTIE: Ministry of Trade, Industry and Energy • MPSS: Ministry of Public Safety and Security • MSICT: Ministry of Science and ICT • MSIF: Ministry of Science, ICT, and Future Planning • NFA: National Fire Agency • NGP: North Gyeongsang Province • NPA: National Policy Agency • NSSC: Nuclear Safety and Security Commission • PC: Pohang City • SGP: South Gyeongsang Province • UC: Ulsan City • UJC: Ulju County

5.2.2.4 Structural Hole - Efficient Nodes with Less Redundancy

Under the assumption that efficient nodes do not have redundant connections, the structural hole was measured by efficiency, which is *1- Redundancy* added up for all the alters

of a node. Table 10 displays the values of redundancy and efficiency of the two cases. The mean of efficiency was higher in the Pohang earthquake with 0.525 but the distribution showed a bit more spread out from the mean in the Pohang case. Even though the mean of the efficiency was higher in the Pohang earthquake, it did not imply a lower mean value of the redundancy. This leads us to investigate the individual nodes and compare the node level efficiencies.

Table 10. Distribution of Structural Hole Measure (Redundancy, Efficiency) in Gyeongju and. Pohang Earthquakes

Measures	Value			
	Redundancy		Efficiency	
	Gyeongju	Pohang	Gyeongju	Pohang
Mean	0.053	0.072	0.447	0.525
Std. Dev.	0.162	0.19	0.339	0.356
Min.	0	0	0	0
Max.	0.932	0.857	1	1

Table 11 below illustrates the organizations with high efficiencies in the Gyeongju and Pohang earthquakes. At first glance, not many common nodes were observed in the first ten nodes with high efficiency except GJC. Also, whereas 8 out of 10 nodes with the highest efficiency value in the Gyeongju earthquake were the local governments, only 3 among 10 were local governments in the Pohang earthquake. In the Pohang case, the central agencies played a distinctive role as structural holes, many of which were not identified in top 20 efficient nodes of the Gyeongju earthquake.

Table 11. Top 20 Efficient Nodes (Structural Hole) in Gyeongju and Pohang Earthquake

No.	Gyeongju Earthquake		Pohang Earthquake	
	Organization	Efficiency	Organization	Efficiency
1	HG	1	MOJ	1
2	GC	1	KFS	1
3	CWC	1	MSICT	1
4	UJC	1	NSSC	1
5	DC	1	KMA	1
6	SJP	1	MOEL	1
7	MPSS	0.85	GJC	1
8	GJC	0.664	GC	1
9	PC	0.633	MIS	0.672
10	MOLIT	0.614	NGP	0.649
11	MOI	0.587	MOF	0.574
12	KCC	0.568	MND	0.553
13	MSIF	0.525	PC	0.546
14	BC	0.520	MOEF	0.524
15	MCST	0.518	MOLIT	0.522
16	MND	0.5	NFA	0.494
17	NPA	0.5	MOEN	0.493
18	MOHW	0.5	NPA	0.474
19	NGP	0.483	MOE	0.474
20	KMA	0.483	MCST	0.471

Acronyms	
• BC: Busan City • CHA: Cultural Heritage Administration • CWC: Changwon City • DC: Daegu City • GC: Gumi City • GJC: Gyeongju City • HG: Haeundae Gu • KCC: Korea Communications Commission • KFS: Korea Forest Service • KMA: Korea Meteorological Administration • MAFRA: Ministry of Agriculture, Food and Rural Affairs • MCST: Ministry of Culture, Sports and Tourism • MIS: Ministry of the Interior and Safety • MND: Ministry of National Defense • MOE: Ministry of Education • MOEF: Ministry of Economy and Finance • MOEL: Ministry of Employment and Labor • MOEN: Ministry of Environment	• MOF: Ministry of Oceans and Fisheries • MOHW: Ministry of Health and Welfare • MOI: Ministry of Interior • MOJ: Ministry of Justice • MOLIT: Ministry of Land, Infrastructure, and Transport • MOTIE: Ministry of Trade, Industry and Energy • MPSS: Ministry of Public Safety and Security • MSICT: Ministry of Science and ICT • MSIF: Ministry of Science, ICT, and Future Planning • NFA: National Fire Agency • NGP: North Gyeongsang Province • NPA: National Policy Agency • NSSC: Nuclear Safety and Security Commission • PC: Pohang City • SGP: South Gyeongsang Province • UC: Ulsan City • UJC: Ulju County

Among the top 20 structural holes of the two cases, some central level agencies were commonly observed: the MOLIT, MCST, MND, NPA, KMA. The efficiency values of these organizations were more or less similar across the cases except KMA, which had an efficiency value of 0.483 in the Gyeongju earthquake and 1 in the Pohang earthquake. The agencies that went through reorganization and commonly had high efficiency in both cases were MPSS, MOI,

MIS, MSIF, and MSICT. The MPSS (0.85) and MIS (0.672), the control centers of disaster management, both served as structural holes with less redundancy. The MOI, whose function was integrated into the MIS, had relatively high efficiency (0.587). The MSIF (0.525) and MSICT (1) which had authority over science and ICT related functions at the time of Gyeongju and Pohang earthquakes respectively, also had high efficiency value.

Some agencies that had recognizable efficiency in one case but not in the other. For instance, KCC and MOHW were included in the top 20 structural holes of the Gyeongju earthquake but not included in the list for the Pohang earthquake. A wider variety of central level agencies was identified as efficient nodes in the Pohang case while not being incorporated in the Gyeongju case. These include: MOJ, KFS, NSSC, MOEL, MOF, MOEF, NFA, MOEN, and MOE. From these results we may gain understanding of how different arrangements of the disaster management system are implemented in response activities.

5.2.3 Sub-Network Level Comparison

The sub-network groups were measured in terms of community and clique. Figure 23 visualizes the clusters of communities produced by employing the CNM algorithm. The communities examined by maximized modularity count each isolated node as one distinct community. In the Gyeongju earthquake, there were 11 communities of single isolated nodes. Excluding such isolated single nodes, the analysis produced 3 clusters. The largest cluster was composed of MPSS, MOHW, MND, MCST, NPA, GJC, DC, SGP, UJC, CWC, GC, HG. The second largest cluster involved KCC, MOI, NSSC, CHA, MOTIE, MOE, MSIF, MAFRA, KMA, and MOEF. The third largest cluster included NGP, UC, BC, PC, and MOLIT.

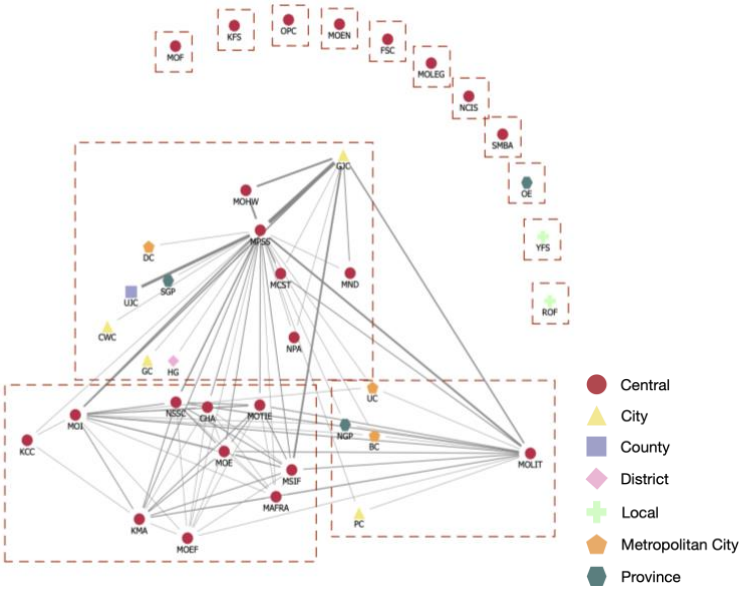


Figure 23. Communities of Gyeongju Network

The sub-network groups measured by clique, a maximal complete subgraph composed of three or more nodes (Hanneman and Riddle, 2005), display results from a somewhat different aspect. That is, the cliques that vary in size have overlapping membership with different cohesion indices. Thus, the key nodes could appear multiple times having different membership in cliques. The cliques with the highest cohesion index in the Gyeongju earthquake included the MPSS, MOLIT, MOI, MSIF, MOE, MOTIE, NSSC, KMA, CHA, and MAFRA/MOEF.

Table 12. Cliques in Gyeongju Earthquake

Cliques	Members	Size	Cohesion Index
Clique 1	MPSS, MOLIT, MOI, MSIF, MOE, MOTIE, NSSC, KMA, CHA, MAFRA	10	7.368
Clique 2	MPSS, MOLIT, MOI, MSIF, MOE, MOTIE, NSSC, KMA, CHA, MOEF	10	7.368
Clique 3	MPSS, MOLIT, MOI, MSIF, GJC	5	2.946
Clique 4	MPSS, MOLIT, MOI, BC	4	2.833
Clique 5	MPSS, MOLIT, MOI, NGP	4	2.833
Clique 6	MPSS, MOLIT, MOI, UC	4	2.833
Clique 7	MPSS, MOLIT, PC	3	2.763
Clique 8	MPSS, MOLIT, MCST, GJC	4	3.317
Clique 9	MPSS, MND, GJC	3	3.5
Clique 10	MPSS, NPA, GJC	3	3.5
Clique 11	MPSS, KCC, KMA, MOI	4	3.163
Clique 12	MPSS, MOHW, GJC	3	3.5

Cohesion index is defined only for undirected graph. It is computed by [the density of internal ties (clique a → clique a) / the density of external ties (clique a → external nodes)].(Cyram, 2021)

Acronyms	
• BC: Busan City • CHA: Cultural Heritage Administration • GJC: Gyeongju City • KCC: Korea Communications Commission • KMA: Korea Meteorological Administration • MAFRA: Ministry of Agriculture, Food and Rural Affairs	• MOLIT: Ministry of Land, Infrastructure, and Transport • MOTIE: Ministry of Trade, Industry and Energy • MPSS: Ministry of Public Safety and Security • MSIF: Ministry of Science, ICT, and Future Planning • NGP: North Gyeongsang Province

• MCST: Ministry of Culture, Sports and Tourism • MND: Ministry of National Defense • MOEF: Ministry of Economy and Finance • MOHW: Ministry of Health and Welfare • MOI: Ministry of Interior	• NPA: National Policy Agency • NSSC: Nuclear Safety and Security Commission • PC: Pohang City • UC: Ulsan City

In the Pohang earthquake, there were 7 communities composed of a single isolated node having no links to other nodes. The largest cluster measured by maximized modularity was composed of the MCST, MOEF, CHA, NFA, MOHW, MOLIT, MOE, MOEN, NPA, MGEF, MND, MOJ, and MOF (Figure 24). There were two second largest communities consisting of 5 nodes. One consisted of the MIS, KMA, NSSC, GJC, and GC, the other involved MOEL, NGP, KFS, PC, and MSICT.

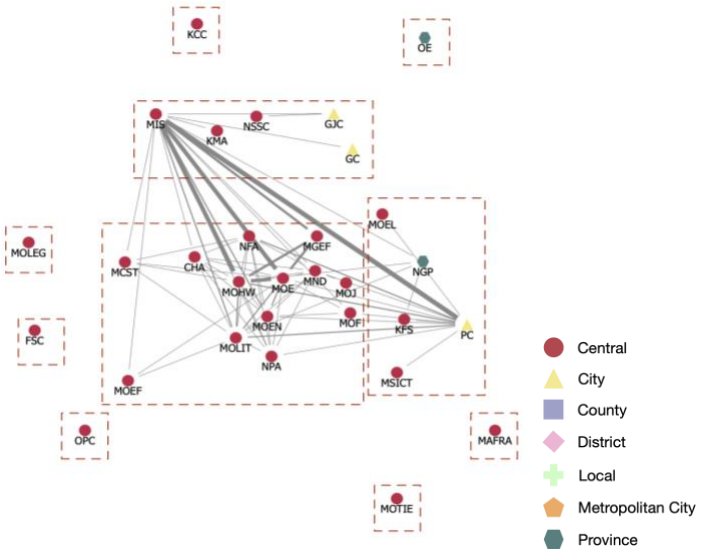


Figure 24. Communities of Pohang Network

The cliques in the table 13 below manifest which agencies are relatively more cohesive. The clique with the highest cohesion index includes MIS, MOE, MOLIT, MOHW, NFA, NPA, MOEN, MND, and CHA. The members of this clique overlap with the largest community except for MIS.

Table 13. Cliques in Pohang Earthquake

Cliques	Members	Size	Cohesion Index
Clique 1	MIS, MOE, MOLIT, MOHW, NFA, NPA, MOEN, MND, CHA	9	6.517
Clique 2	MIS, MOE, MOLIT, MOHW, NFA, NPA, MOEN, MND, PC	9	5.727
Clique 3	MIS, MOE, MOLIT, MOHW, NFA, MCST	6	3.692
Clique 4	MIS, MOE, MOLIT, MOEF	4	3.152
Clique 5	MIS, MOE, MOF, MOEN, PC	5	3.472
Clique 6	MIS, MOE, MGEF, MOHW	4	3.152
Clique 7	MIS, NGP, MOHW, MOLIT	4	3.152

Cohesion index is defined only for undirected graph. It is computed by [the density of internal ties (clique a → clique a) / the density of external ties (clique a → external nodes)].(Cyram, 2021)

Acronyms	
• CHA: Cultural Heritage Administration • MCST: Ministry of Culture, Sports and Tourism • MGEF: Ministry of Gender Equality and Family • MIS: Ministry of the Interior and Safety • MND: Ministry of National Defense • MOE: Ministry of Education	• MOF: Ministry of Oceans and Fisheries • MOHW: Ministry of Health and Welfare • MOLIT: Ministry of Land, Infrastructure, and Transport • NFA: National Fire Agency • NGP: North Gyeongsang Province

• MOEF: Ministry of Economy and Finance • MOEN: Ministry of Environment	• PC: Pohang City

In all, the major sub-network group in the Gyeongju earthquake involved the MOI, MSIF, MOE, MOTIE, NSSC, KMA, CHA, MAFRA, and MOEF while in Pohang earthquake it was composed of the MOE, MOLIT, MOHW, NFA, NPA, MOEN, MND, and CHA. These are the combined results of sub-networks groups measured both by modularity and clique in each case. The organizations common in both cases were the MOE and CHA. The nodes distinctive to the major community in the Gyeongju earthquake were the MOI, MSIF, MOTIE, NSSC, KMA, MAFRA, and MOEF. In the Pohang earthquake, the MOLIT, MOHW, NFA, NPA, MOEN, and MND were the noticeable nodes compared to the Gyeongju case.

5.3 Discussion

The results of network analysis based on the government's daily report on earthquake cases revealed that there were implications with regards to reorganization and interorganizational networks. The discussions on the results of the analysis will be laid out at network, node, and sub-network levels based on the framework of complex adaptive systems.

5.3.1 Network Level: Systems Pre- and Post-Exogenous Shock

5.3.1.1 Higher Centralization to a Focal Node in Gyeongju Earthquake vs. Higher Overall Density in Pohang Earthquake

The size of the whole network indicated that while the number of nodes was slightly higher in Gyeongju case (32) than Pohang case (30), Pohang had a bigger diameter of 4 compared to Gyeongju's diameter of 2. This indicates that though the number of participants of a network may be greater, the distance reaching from one end to the other end could be smaller. Density, the number of existing links out of all the possible links, was greater in the Pohang earthquake. However, this condition was reversed when the centralization, how centralized the network is towards the focal node, was measured. That is, the Gyeongju earthquake showed higher degree and betweenness centralization value. Whereas the density of the overall network noted the speed at which information flowed was higher in the Pohang earthquake response activities, the level of centralization to the focal nodes was higher in the Gyeongju earthquake responses. It could be interpreted that the MPSS, as the focal node in the Gyeongju case, played a dominant role in response activities making other organizations rely on its functions. In part this result may be attributed to the unprecedented natural hazard for which most of the participating organizations lacked experience, and because the MPSS was the organization mainly dealing with safety and security related functions.

Some isolated nodes were present in both cases and included the Office for Government Policy Coordination (OPC), Financial Services Commission (FSC), and Ministry of Government Legislation (MOLEG)[31]. These organizations are incorporated directly under the

[31] Though undistinguishable in English name of the organization, the head of MOLEG is a vice-ministerial level public official unlike other ministries where the head is ministerial level.

Prime Minister rather than under other ministerial level agencies. Such a structure could have caused these organizations to work more independently from other organizations in response to the earthquakes. Moreover, from the consistency of operating independently of other organizations, they are less likely to be affected by exogenous shocks such as reorganization.

Certain organizations were isolated from the network in one case, but not in the other. The Ministry of Oceans and Fisheries (MOF), Korea Forest Service (KFS), and Ministry of Environment (MOEN) were disconnected from other organizations in response to the Gyeongju earthquake but were incorporated into the network that responded to the Pohang earthquake. In contrast, the Ministry of Agriculture, Food, and Rural Affairs (MAFRA), Ministry of Trade, Industry, and Energy (MOTIE), and Korea Communication Commission (KCC) were isolated in the Pohang response but were linked to the network in the Gyeongju response. While the response activities of the Gyeongju case encompassed a wider range of fields such as agriculture, trade, industry, energy, and communications, the response activities of Pohang focused relatively more on natural environmental issues.

5.3.2 Node Level: Change in Agents' Patterns of Interactions

5.3.2.1 Centralized Connectedness in the Gyeongju Earthquake vs. Distributed Connectedness in the Pohang Earthquake

The mean of degree centrality, denoting the influence by having many connections to other nodes, was higher in the Pohang earthquake than in the Gyeongju earthquake. This implies that overall, the organizations in the Pohang response network were more connected to others. In the Gyeongju earthquake various levels of local governments were involved, many of them directly connected to the MPSS but lacking links to other agents. In contrast, in the Pohang

network, local governments had ties to agents other than the MIS. Such results demonstrate that the position of the local governments had changed from being primarily dependent on MPSS to a more dispersed state, having links to organizations other than the MIS.

The network revealed that while the organizations heavily relied on the MPSS in terms of connectedness in the Gyeongju response, the actors in the Pohang response network that had the corresponding roles had relatively less reliance on the MIS. The key actors with high connectedness to others did not overlap much except for the Ministry of Land, Infrastructure, and Transport (MOLIT). The major organizations with many connections to others in the Gyeongju case were the MOLIT, Ministry of Interior (MOI), and Ministry of Science, ICT, and Future Planning (MSIF). In the Pohang case, MOLIT, Ministry of Education (MOE), Ministry of Health and Welfare (MOHW), National Police Agency (NPA), National Fire Agency (NFA), Ministry of National Defense (MND), and Ministry of Environment (MOEN) were the major organizations having many ties. Such a distinction not only shows the focus put on the respective response activities but also the relative importance of the organizations in relation to other actors. With respect to the local governments, those of the Pohang response network had comparably higher connectedness to other agents in the network.

5.3.2.2 Shifts of Agents Linked to Influential Agents

The influence of a certain node is also determined by its ties to other influential nodes. Measured by eigenvector centrality, the properties of central level agencies had some similarities and some discrepancies. Central level agencies with high overall connectedness but comparatively low connectedness to major actors were observed in both cases. Among them, an organization common to both cases was the Ministry of Land, Infrastructure and Transport (MOLIT). Whereas the MOLIT had many links to other organizations, it was less likely to be

influential since organizations connected to the MOLIT did not have many ties to others. Some discrepancies among central level agencies associated with focal organizations were also observed. First, the Ministry of Trade, Industry and Energy (MOTIE) and Korea Meteorological Administration (KMA) were relatively more impactful in the Gyeongju earthquake by having connections to the key organization. On the contrary, the Ministry of Education (MOE) and Ministry of Health and Welfare (MOHW) had more ties to major organizations in the Pohang earthquake. It could be interpreted that in the Gyeongju earthquake organizations sharing information on the status of the disaster and its impacts on industry and trade had an urgent need to be linked to the organizations with greater influence. In the Pohang earthquake, the focus had shifted to the tasks of maintaining health and education, and the organizations related to such functions were tied to the influential organizations.

5.3.2.3 Higher Reliance on the Lead Agency in the Gyeongju Earthquake vs. Dispersed Influence in the Pohang Earthquake for Communication

As expected, the lead disaster management agency in each earthquake - MPSS in Gyeongju and MIS in Pohang - had the maximum betweenness value, serving as critical bridges linking other organizations. Much like the pattern observed in the concentration of degree centrality, the Gyeongju network showed high reliance on the MPSS whereas in the Pohang network, the role of mediator was distributed among local governments such as Pohang city and Gyeongju city following the MIS. This reveals the fact that local actors were at a more influential position in the Pohang earthquake associated with communicative capacity. In addition, the Ministry of National Defense (MND), Ministry of Health and Welfare (MOHW), Ministry of Education (MOE) were able to bridge with other organizations in the Pohang earthquake while less so in the Gyeongju earthquake. These organizations were also distinctive

in the Pohang case in terms of connectedness and being connected to focal organizations. With regard to communicative power, the Pohang network demonstrated relatively disseminated authority. In other words, whereas the agents in the Gyeongju network had to communicate by way of the MPSS, in the Pohang earthquake, there were alternative paths through which organizations could interact, other than via the MIS.

5.3.2.4 Efficient Local Governments in the Gyeongju Earthquake vs. Higher Overall Efficiency in the Pohang Earthquake

The structural holes measured by efficiency were quite dissimilar in the two cases. Distinctive to the Gyeongju earthquake, local governments took a major role as structural holes with high efficiency. Among the top 20 efficient nodes, agencies common to both cases were the Ministry of Land, Infrastructure and Transport (MOLIT), Ministry of Culture, Sports and Tourism (MCST), Ministry of National Defense (MND), National Police Agency (NPA), and Korea Meteorological Administration (KMA). Efficient organizations that went through reorganizations were the MPSS and Ministry of Interior (MOI) which were reorganized as MIS. Moreover, the Ministry of Science, ICT and Future Planning (MSIF) was reorganized into the Ministry of Science and ICT (MSICT) but managed to keep high efficiency. In all, it implies that these organizations were all able to maintain efficient relationships despite recurring exogenous shocks. Therefore, to develop a stable disaster management system, these organizations should be considered as hubs of strategic action fields.

5.3.3 Sub-Network Level: Varying Degrees of Dependencies within and across Groups

The configurations of the largest cluster in each network disclosed somewhat disparate results. In the largest cluster of the Gyeongju response network, more than half were the local governments. In contrast, no local government was found in the largest cluster of the Pohang network. Overlapping agents in the largest cluster of the two cases were the Ministry of Health and Welfare (MOHW), Ministry of Culture, Sports and Tourism (MCST), and National Policy Agency (NPA). In addition, the Nuclear Safety and Security Commission (NSSC) and Korea Meteorological Administration (KMA) were also found to be within the same cluster in both cases denoting their close relations to each other.

The clique, or the maximal complete subgraph with three or more nodes, was another indicator for subnetwork level group cohesion. In both cases, the Ministry of Land, Infrastructure and Transport (MOLIT), Ministry of Education (MOE), and Cultural Heritage Administration (CHA) were incorporated within the clique with the highest cohesion index along with the MPSS and MIS in the Gyeongju and Pohang earthquake respectively. It is noteworthy that these organizations had high cohesion although their functions do not seem to be closely related to one another. This might be due to the institutional setting that enforced these organizations to come together in disasters. Specifically, the establishment of the Central Disaster and Safety Countermeasures Headquarters (CDSCHQ) required relevant agencies to work closely with each other to accomplish rapid response activities. Although such institutions provided the same environments for all, some organizations distinctively had close relationships with one agency, but not others.

When the cliques with the highest cohesion index were compared between the Gyeongju and Pohang cases, members of the clique were quite different, except for the organizations

mentioned in the previous paragraph. In the Gyeongju earthquake, the Ministry of Science, ICT and Future Planning (MSIF), Ministry of Trade, Industry and Energy (MOTIE), Nuclear Safety and Security Commission (NSSC), Korea Meteorological Administration (KMA), and Ministry of Agriculture, Food, Rural Affairs (MAFRA) constituted the clique with the highest cohesion. The organizations with the highest cohesion in the Pohang earthquake were the Ministry of Health and Welfare (MOHW), National Fire Agency (NFA), National Police Agency (NPA), Ministry of Environment (MOEN), and Ministry of National Defense (MND). While the key clique of the Gyeongju network presented a broader array of functions within - encompassing ICT, trade, nuclear safety, agriculture etc. - the functions of the major clique of the Pohang network were relatively more focused towards response activities such as health, first response, and defense. Such a change in the constitution of the major clique implies the dynamics of the system as well as the institutional settings as starting conditions.

In all, by comparing the major community and clique in each case, I could distinguish which organizations maintained close connections over time despite exogenous shocks and which had undergone changes. Table 14 below illustrates the organizations that continued close relationships despite changes and those that shifted towards a new configuration. Yet, the results of the sub-network groups were not identical across measurements. For instance, the Nuclear Safety and Security Commission (NSSC) and Korean Meteorological Administration (KMA) were incorporated within the same community in both cases when measured by community (modularity). However, in terms of cliques, these agencies were involved in the same clique only in the Gyeongju earthquake, because communities and cliques emanate from different approaches to measuring group cohesion. The community-finding algorithms are stochastic, indicating that each time it is run, there could be slight differences. A clique, on the other hand,

is a more straightforward way of detecting the existing groups. Instead of choosing one, I employed both measurements to draw out a more comprehensive understanding about the sub-network groups. And thus, the results should be read carefully in the context of results from other levels of analysis and of the environment.

Table 14. Comparison of Major Communities and Cliques

Measurement	Gyeongju Network	Pohang Network
Community - Modularity	1) MPSS, MOHW, MND, MCST, NPA, GJC, DC, SGP, UJC, CWC, GC, HG 2) KCC, MOI, NSSC, CHA, MOTIE, MOE, MSIF, MAFRA, KMA, MOEF 3) NGP, UC, BC, PC, MOLIT	1) MCST, MOEF, CHA, NFA, MOHW, MOLIT, MOE, MOEN, NPA, MGEF, MND, MOF 2) MIS, KMA, NSSC, GJC, GC 3) MOEL, NGP, KFS, PC, MSICT
Clique	1) MPSS, MOLIT, MOI, MSIF, MOE, MOTIE, NSSC, KMA, CHA, MAFRA 2) MPSS, MOLIT, MOI, MSIF, MOE, MOTIE, NSSC, KMA, CHA, MOEF	1) MIS, MOE, MOLIT, MOHW, NFA, NPA, MOEN, MND, CHA 2) MIS, MOE, MOLIT, MOHW, NFA, NPA, MOEN, MND, PC

Organizations that maintained close relationships across two cases	CHA, MOE
Organizations that had close relationships in one case but not the other	● Gyeongju - MSIF, MOTIE, MAFRA ● Pohang - NFA, MOEN

Acronyms	
• BC: Busan City • CHA: Cultural Heritage Administration • CWC: Changwon City • GC: Gumi City • GJC: Gyeongju City • HG: Haeundae Gu • KCC: Korea Communications Commission • KFS: Korea Forest Service • KMA: Korea Meteorological Administration • MAFRA: Ministry of Agriculture, Food and Rural Affairs • MCST: Ministry of Culture, Sports and Tourism • MGEF: Ministry of Gender Equality and Family • MIS: Ministry of the Interior and Safety • MND: Ministry of National Defense • MOE: Ministry of Education • MOEF: Ministry of Economy and Finance • MOEL: Ministry of Employment and Labor • MOEN: Ministry of Environment	• MOHW: Ministry of Health and Welfare • MOI: Ministry of Interior • MOJ: Ministry of Justice • MOLIT: Ministry of Land, Infrastructure, and Transport • MOTIE: Ministry of Trade, Industry and Energy • MPSS: Ministry of Public Safety and Security • MSICT: Ministry of Science and ICT • MSIF: Ministry of Science, ICT, and Future Planning • NFA: National Fire Agency • NGP: North Gyeongsang Province • NPA: National Policy Agency • NSSC: Nuclear Safety and Security Commission • PC: Pohang City • SGP: South Gyeongsang Province • UC: Ulsan City • UJC: Ulju County

5.3.4 Dynamics of Environment

Considering reorganization as an exogenous shock stimulating subsequent changes, the disaster management system faced the need to operate within the dynamics of such an

environment. The history of working together induces changes to the agents, and to the groups of agents, and ultimately to the network. Holland (2012) contended that agents form environments for other agents, and thus, even changes to a single agent may bring far-reaching impacts to other agents, groups, and the network. Several changes in the environment are considered to have affected the network, based on interviews with the public officials working within the MIS.

In general, the change of environment could be discussed in terms of i) central-central and ii) central-local relationships. First, the relationship between the central agencies that was predominantly impacted by the reorganization from the MPSS to MIS is associated with collaboration. Although the MPSS was established to achieve collaboration among the agencies by legally giving the MPSS authority to control and coordinate disaster and safety policies, other agencies were not supportive of the MPSS exerting control over them.

> *"Though the MPSS had the legal authority to establish CDSCHQ and control disaster and safety policies, it did not operate as it had been intended. This was due to the fact that this organization [MPSS] was more or less horizontal to other agencies, making it difficult for them to comply with its authority. … Despite the fact that the MPSS was upgraded to a ministerial level agency*[32] *[whereas NEMA was administrator level agency]*[33] *other ministries and agencies still deemed it equal to NEMA"* (Interviewee 1, personal communication, Nov. 27, 2019)

[32] The level of central agencies are determined by the leader of each agency i) Minister ii) Vice-Minister iii) Administrator/Commissioner in the order of higher to lower levels

[33] Contents within the brackets are added by the researcher considering the context of the interview.

Such an uncooperative nature changed over time, along with the newly organized MIS.

> *"With time, other ministries came to accept controlling and coordinating functions of the MIS. They are even dependent on us [MIS]. So functionally, control and coordination has been strengthened …"* (Interviewee 4, personal communication, Dec. 11, 2019)

> *"After being reorganized into the MIS … the Minister of the MIS seems more powerful than the Minister of the MPSS. So it [inducing cooperation from other organizations] requires less effort."* (Interviewee 6, personal communication, Dec. 11, 2019)

However, some interviewees argued that the MIS still lacked sufficient authority to coordinate other ministerial level agencies.

> *"It is possible for a Prime Minister to command other ministers, but it's not easy for a minister to command other ministers"* (Interviewee 3, personal communication, Dec. 5, 2019)

> *"What's unique about the MIS is that their function is to intervene other agencies [on disaster management functions] and elicit their collaboration, but they are at an equal position to other ministers. So it is rather difficult [to derive other ministers' collaboration]."* (Interviewee 8, personal communication, Dec. 11, 2019)

Thus, the institutional setting, granting MIS the authority to establish and lead CDSCHQ was considered "*a final defending privilege*" where other organizations are legally required to follow what MIS asks them to do (Interviewee 8, personal communication Dec. 11, 2019).

Some positive notions were made on the MPSS with regard to communication between certain agencies and focusing attention to safety and security.

> *"Since the Fire Agency and Coast Guard were incorporated within the same organization [MPSS], communication between them was enhanced."* (Interviewee 5, personal communication, Dec. 11, 2019)

> *"In a broader view, while the priority of the MIS is not on safety, the MPSS prioritized safety tasks because it was their sole function."* (Interviewee 11, personal communication, Dec. 27, 2019)

Since the *Sewol* ferry disaster generated criticism on miscommunication between those two agencies, the MPSS was created as a reaction to the public demand. By incorporating the NFA and the KCG within one ministry, communication was expected to be intensified. Furthermore, unlike the MIS which had many other functions and tasks on the list, the MPSS was able to put focus on safety tasks.

The shift of the environment was also observed with respect to the relationship between the central agencies and the local governments. The major issue was that the local governments were more likely to comply with the central agencies when they thought a certain agency had the power to influence them.

"When the Deputy Minister [of the MIS] says [something], the Vice Governor [of a local government] acts. This is because the Vice Governor later [could] become(s) the Deputy Minister … But this wasn't so in the MPSS. [So] There was a disconnection" (Interviewee 1, personal communication, Nov. 27, 2019)

"The role of the MIS was to take actions at the local scene. Since it had good connections to the local governments and had active communications and networks with them, the MIS was able to drive the local governments." (Interviewee 4, personal communication, Dec. 11, 2019)

What the MPSS did not have, compared to the MIS in relation to the local governments, was the power to urge local governments to act as their counterpart. Such a power was stated as access to the resources, authority over personnel, and financial aids.

"The problem of the MPSS was that they had to work with the local organizations … there are local counterparts in the MIS [that the MPSS did not have]. … In the management perspective, it is the power. If they don't listen and act accordingly, it's difficult to manage." (Interviewee 5, personal communication, Dec. 11, 2019)

"After the Disaster and Safety special subsidy had been enacted, it [supporting the local activities] was intensified. … [But] the MOI was separated, so it was not easy [for the MPSS] to drive local governments. Now with the MIS, local governments are more cooperative." (Interviewee 6, personal communication, Dec. 11, 2019)

"The biggest linkage between the central and local government (Si/Do) is that the MIS has the authority to appoint the Vice Governor of the local governments." [34] (Interviewee 7, personal communication, Dec. 11, 2019)

"The local governments view that we [MIS] have strong power since we [MIS] have the departments dealing with the local personnel and finance." (Interviewee 8, personal communication, Dec. 11, 2019)

"The limitation of the MPSS was [though] disaster management was impossible without connections to the local governments to direct the local scene, the MPSS had no authority to control them. At that time, the MOI had the authority. After reorganization, the MIS encompassed [the power over] the local. ... Especially at the Pohang earthquake, [the MIS] supported the local doing their first responses at the local. The Central Disaster Management Support Group aided other organizations and departments functioning as a kind of a linkage." (Interviewee 9, personal communication, Dec. 12, 2019)

"Since the MPSS was an agency that imposed responsibilities [on other agencies], they had no power. ... Having authority over human resources and budget etc. is critical for

[34] <Local Autonomy Act> [Enforcement Date 25. Dec, 2019.] [Act No.16057, 24. Dec, 2018., Partial Amendment] Article 110 (3) states that Vice Governors to be appointed by the President "through the Minister of the Interior and Safety"

successful disaster management. … The MPSS had no such power." (Interviewee 10, personal communication, Dec. 12, 2019)

In sum, assessments varied. Some viewed that central organizations acknowledged the controlling role of the MIS and became more cooperative. Others argued that the MIS still lacked sufficient authority to coordinate other agencies at the equivalent level. On central-local relationships, however, most of the interviewees asserted that the MIS was better at stimulating local governments in disaster management. This was considered to be due to their power over resources, personnel, and financial aid.

5.3.5 Adaptation and Outcomes

The results of the network analysis demonstrated how agents, niches, networks were formed and reformed in each case. As discussed, these are the consequences of agents changing their internal models and niches creating new rules according to the new environment. In other words, organizations and groups of organizations adjusted their internal models and rules to adapt to the dynamic environment. The emergent system that resulted from the adaptation (Mitleton-Kelly, 2003) will be considered as a preliminary outcome for the specific purposes of this chapter, which is to capture and compare the networks of the two earthquake cases.

The most apparent discrepancy between the networks of the two cases was the extent of centralization towards the major organizations, i.e. the MPSS and MIS. Notably, the Gyeongju network was centralized to the MPSS in terms of both degree and betweenness whereas the Pohang network was relatively more dispersed. This was also observed at the node level where the degree, eigenvector, and betweenness centralities were largely concentrated in the Gyeongju

earthquake. Challenged by the unprecedented earthquake, agents in the Gyeongju earthquake relied on the MPSS. However, the dependency on the major organization decreased in the Pohang earthquake. Interview also indicated that the current disaster management system acted more organically.

> *"The present [Jaein Moon] administration responds to the disaster very much organically. Not acting based on a fixed scenario. When an accident occurs, even early in the morning, the Blue House calls on related agencies."* (Interviewee 1, personal communication, Nov. 27, 2019)

It could be understood as an adaptation to the environment in which a cooperative response was engendered. Rather than relying on a certain agency to take sole control, a network was developed with more diffused power.

The results of the interview and of the network analysis seemed somewhat inconsistent with regard to the relationships between the local governments and central agencies. While many of the interviewees asserted that the MPSS did not have the sufficient power to spur local governments to act upon their request, the results from the network analysis revealed that local governments were highly reliant on the MPSS. That is, the local governments had more connections to the MPSS than to other agencies and were linked to other agencies through the MPSS. This is comparable to the Pohang earthquake responses where local governments actively interacted with organizations other than the MIS. Apart from their willingness to cooperate with the MPSS, the local governments were bound by law to comply with the control center of disaster management. Thus, it could be assumed that there was a gap between the

implementation at the local level and the development of formal ties at the central level in the Gyeongju earthquake. In contrast, relatively diffused ties in the Pohang earthquake were observed from the network analysis. It is inferred that the MIS was able to bring out cooperation from the local governments who themselves formed ties to other agents based on dispersed communicative power.

Another adaptation was the shift in focus observed from the change in major nodes and communities. Table 15 below demonstrates the change in fields based on key nodes and communities. The organizations in the table are distinctive to each case. In other words, the key organizations common to both cases were eliminated for the purposes of detecting changes. Likely, the MPSS and MIS were excluded from the list since they were at the center for most of the measurements. While in the Gyeongju network the focus was quite broad, encompassing the functions of agriculture, trade, industry, energy, communication, the focus of the Pohang network narrowed down to oceans and fisheries, forest, environment. In terms of connectedness, internal affairs, science and ICT functions were at the center in the Gyeongju case while education, health, national defense, environment played a key role in the Pohang case. Trade, industry, and meteorological function were linked to influential organizations in Gyeongju which shifted towards education and health in Pohang. Major communities and cliques also shifted from the organizations dealing with science, ICT, trade, industry, energy, agriculture to fire and environments.

Table 15. Comparison of Fields Based on Key Nodes and Community/Clique

	Gyeongju Earthquake	Pohang Earthquake
Isolated nodes	MOF, KFS, MOEN * Fields: oceans, fisheries, forest service, environment	MAFRA, MOTIE, KCC * Fields: agriculture, food, rural affairs, trade, industry, energy, communication
Degree centrality	MOI, MSIF * Fields: internal affairs, science, ICTs	MOE, MOHW, NPA, NFA, MND, MOEN * Fields: education, health, welfare, police, fire, national defense, environment
Eigenvector centrality	MOTIE, KMA * Fields: trade, industry, energy, meteorology	MOE, MOHW * Fields: education, health, welfare
Community/ Clique	MSIF-MOTIE-MAFRA * Fields: science, ICTs - trade, industry, energy - agriculture, food, rural affairs	NFA-MOEN * Fields: fire - environment

Acronyms	
• KCC: Korea Communications Commission • KFS: Korea Forest Service • KMA: Korea Meteorological Administration • MAFRA: Ministry of Agriculture, Food and Rural Affairs • MND: Ministry of National Defense • MOE: Ministry of Education • MOF: Ministry of Oceans and Fisheries • MOEN: Ministry of Environment	• MOF: Ministry of Oceans and Fisheries • MOEN: Ministry of Environment • MOHW: Ministry of Health and Welfare • MOI: Ministry of Interior • MOTIE: Ministry of Trade, Industry and Energy • MSIF: Ministry of Science, ICT, and Future Planning • NFA: National Fire Agency • NPA: National Policy Agency

Adaptation after experiencing disaster was identified in organizational reforms. Many interviewees mentioned that the government came to strengthen earthquake-related departments after the Gyeongju earthquake by creating new organizations or activating institutions that existed, but had not been implemented.

> *"It was the MPSS at the time of the Gyeongju earthquake, there was fierce criticism since we had never dealt with earthquakes. After the Gyeongju earthquake, an earthquake department was generated and organizational changes followed. … There was an increase of earthquake experts."* (Interviewee 1, personal communication, Nov. 27, 2019)

> *"After the Gyeongju earthquake, the organization expanded. The divisions related to earthquake risks were created and the R&D division also was enlarged. The MOLIT strengthened earthquake related functions at division level as well. After the Pohang earthquake, changes were focused more on policy rather than organizations."* (Interviewee 2, personal communication, Dec. 3, 2019)
>
> *"At the Pohang earthquake, Central Disaster Management Support Group was activated for the first time"* (Interviewee 3, personal communication, Dec. 5, 2019)

Though not ultimate, the outcomes, or emergence of a new system, was observed through comparison of the two earthquakes. Along with the structural changes of individual organizations, more attention was paid to enhance the disaster management system as a whole.

This was not limited to a single agency or local government that was directly affected. Such improvements were noticeable in the Pohang earthquake.

> *"Gyeongju earthquake brought about the most systematic and comprehensive investment of the government action associated with earthquakes. Though the damage was marginal, measures for earthquake preparedness were developed and seismographs were installed in KMA making it possible to promptly observe the shakes and report them. The government organizations - KMA, MIS etc. - were enlarged and the* ***personnel*** *and* ***facilities*** *of the local governments were intensified. In addition, the* ***budget*** *for earthquake resistance increased [due to the Gyeongju earthquake]. ... Pohang earthquake proved the consequences of such investments. Though the damage was larger, the emergency alert was distributed much faster and the decision making at the central level was rapid [compared to the Gyeongju earthquake]."* (Interviewee 10, personal communication, Dec. 12, 2019)

In all, adjustments were made to the internal models of organizations. The internal models, on which organizations make decisions, were reflected in the network, sub-network, and node level features. Over the time period between the two earthquakes, the network came to be more dispersed throughout. In other words, reliance on specific nodes decreased. The fields of major focus as seen from node and sub-network level measurements, narrowed from encompassing a variety of functions - ICT, trade, industry, science, agriculture etc. - to fields with a more intimate relationship to local implementation - health, fire, police, education, and environment. The emergence of the "new" system was not only due to the structural changes,

but also comprehensive attention toward investment of resources - facilities, personnel, and budget.

5.4 Conclusion

In this chapter, the properties of networks in the Gyeongju earthquake and Pohang earthquake were explored at different levels. Various measurements were employed to identify what had been changed or what had not been changed in networks of organizations comprising the disaster management system of Korea. Such similarities or differences were assumed to imply the relationship between reorganization and interorganizational networks. The results are summarized in the table 16 below.

The agents within the disaster management system as a complex adaptive system were the organizations affected by exogenous shock - the reorganization. The internal models were embedded within each organization creating patterns at the aggregated group level. Individual organizations in the Gyeongju earthquake tended to be more reliant on the MPSS, the control center of disaster management. The pattern had changed in the Pohang earthquake where more dispersed connectedness and communication were observed.

The change of environment among the central agencies was that whereas the MPSS had public safety and security as its sole function, the MIS engaged broader functions other than safety. Ideally, concentration of safety functions should have enhanced implementation, but as interview accounts indicate, it was difficult for the MPSS to draw support from other central agencies. As seen from the network structure, the local governments were more closely tied to the MPSS while serving as structural holes of the network in the Gyeongju earthquake. One of

the possible interpretations to understand the inconsistency between the perceived uncooperative nature and the structural intimacy of the local governments with the MPSS is that the authority of the MPSS had was intentionally generated as a result of the lessons learned from the ferry *Sewol* disaster. In contrast, the MIS, by design, had the resources and power to urge local governments to act upon their requests. This organizational structure was set as a different starting condition between the Gyeongju earthquake and the Pohang earthquake.

The fields of focus at the sub-network group level as seen from the clusters of community and cliques had also changed. In the Gyeongju earthquake, the major groups embraced a broader set of fields while the Pohang earthquake was more focused on the fields closely related to disaster response functions. This is comparable to the network and node level results, where highly centralized structures were identified. While in the Gyeongju earthquake the network was centralized to key nodes, but the major group encompassed a wide variety of fields, in the Pohang earthquake, the network was relatively dispersed, but the focus of the major group converged to functions directly related to disaster management. Thus, it could be concluded that through adaptation, the network shifted from structural concentration with greater dependence on key nodes to functional concentration on major subnetwork groups.

Table 16. Summary of Network Comparison

<table>
<tr><th>Levels</th><th>Gyeongju Earthquake</th><th>Pohang Earthquake</th></tr>
<tr><td>Network Level</td><td>* High centralization</td><td>* High overall density</td></tr>
<tr><td rowspan="2">Sub-Network Level (community, clique)</td><td>* A broader array of fields - science, ICT, trade, industry, energy, agriculture, food etc.</td><td>* Fields more focused on response activities - first response, environment, health etc.</td></tr>
<tr><td colspan="2">* CHA and MOE maintained close relationships across cases
- Fields of cultural heritage and education</td></tr>
<tr><td rowspan="2">Node Level</td><td>* Centralized connectedness, communication
* Local governments had relatively high efficiency</td><td>* Distributed connectedness, communication
* High overall efficiency</td></tr>
<tr><td colspan="2">* MOLIT with high local connectedness but less ties to influential node</td></tr>
</table>

6.0 Linking Government Reorganization with Network Effectiveness

This chapter will identify the linkage between structural rearrangement of government organizations and effectiveness of networks, based on the assumption that such rearrangements bring about differences in collective values of respective organizations. According to the institutional approach to reorganization, the collective values of organizations are critical in understanding how organizational changes are induced. Not only do organizations depend on the external environment, but they are also affected by cultural and ideational aspects within them (Peters, 1992). Referring to the concepts of complex adaptive systems, the internal models of each agent change adapting to the environmental changes including the structural reform. Such an adaptation influences other agents, which in turn reshapes the network as a whole.

A pattern matching technique is applied to the earthquake response datasets comparing the empirical patterns with the theoretical patterns. First, propositions will be derived based on the theories that support each argument. Then counter-theories having different accounts of patterns will be addressed. In the second section, the empirical patterns will be identified and matched with the theoretical patterns to see whether the propositions were supported or not. Evidence from both structural network analysis of government reports and interview statements will be employed to examine the coherence of propositions. Finally, based on the result of the match between theories and counter theories with the empirical results, the theories will be confirmed, disapproved, or refined.

6.1 Theories and Propositions

To answer Research Question 2, "In what ways does government reorganization influence network effectiveness in disaster management?" two aspects will be considered. One is the consolidation of either similar or dissimilar functions. Theories linking such types of consolidation to performance outcomes, network effectiveness in this study, will be used as a basis for deriving propositions. Second, the structural aspect of having a core central agency within the network will be examined to assess its relationship to network effectiveness. Factors associating these two aspects will be addressed, creating a link between the two which are proposed to have an impact on network effectiveness.

As discussed in Chapter 2, South Korea has undergone numerous central level reorganizations with a strong presidential authority over them. Consequently, government organizations have been merged or separated according to the different emphases that presidents had put. This was also noticeable in reorganizations of disaster management agencies, where consolidations of functions were identified. The major disaster management agencies in the Gyeongju earthquake and Pohang earthquake were also the consequences of reorganization that had distinct features both functionally and structurally. As the first step towards matching theories to empirical data, the conceptual framework will be developed based on the literature.

First, the consolidation of organizations is classified into two features - constituted of similar or dissimilar functions - which are proposed to have disparate impacts on network effectiveness. The consolidation, or mergers, of government organizations had been used as a standard means of diminishing the number of agencies, and thus expanding executive control (Musicus, 1964). However, as Wilson (1989) argued, merely moving "the boxes" on government organizational charts, may rather cause disturbance. Admitting the fact that

deriving empirical evidence of consolidation is quite problematic, this research focuses more on how the two different forms of consolidation are connected to network effectiveness.

Classifying the consolidation in terms of function is important since it focuses on 'how it works' instead of what it looks like. Hult (1987) asserted that consolidating interdependent organizations is more likely to generate changes in relationship and performance when compared to mergers of organizations with dissimilar functions (Hult, 1987; Thomas, 1993). One critical assumption is that performance outcome at an individual organizations' level corresponds to network effectiveness at the network level but these two are not identical. Therefore, the linkage between reorganization and network effectiveness is sought contingent on arrangement of functions. Meanwhile, Wilson (1989) doubted the effects of mergers arguing that the mergers bring success only when the core tasks are redefined. For example, in establishing the Department of Health, Education, and Welfare, different cultures, outlook and congressional supporters were maintained independent of other component bureaus (Wilson, 1989; Thomas, 1993).

Second, there is a link between the structural aspect of the network and consolidation of functions, which may affect network effectiveness. Milward and Provan (1995), whose research is seminal in the network effectiveness literature, asserted that the success of a network depends on the structure and the context. They argued that network integration is acquired by having a central agency reinforces network effectiveness (Milward and Provan, 1995). Mechanisms of network integrations include information, communication systems (Klijn, 1996; Jennings and Ewalt, 1998; Provan and Sebastian, 1998; Agranoff, 2003) and joint activities (Jennings and Ewalt, 1998; Shortelli et al. 2002; Bazzoli et al. 2003). These mechanisms connect functions to structure in networks, specifically through organizations that have consolidated similar

functions. This proposition is based on the Jennings and Ewalt's (1998) research that observed the relationship between administrative consolidation and program outcomes. Although their focus was on program consolidation, it is considered that consolidating similar programs and functions are sufficiently compatible to infer the relationship between consolidation of functions and outcomes.

While consolidations are often used to centralize the points of control, merging similar functions into one organization also has analogous effects to creating an independent agency. This most likely occurs in the context of Korea when reorganizations take place with the president at the center. Even if an organization takes the form of an independent agency, it is improbable that it is fully independent from executive control. Rather, it would be more relevant to investigate the change in the arrangement of functions resulting from reorganization. By consolidating similar functions into one organization, subordination of other functions would be decreased much like the anticipated result of creating an independent organization (Wise, 1989; Thomas, 1993). The proposition is that incorporating safety and disaster related functions into one organization would be advantageous in sharing information, use of communication systems, and joint activities in disaster management. In contrast, inclusion of these functions in a larger department where other functions are likely to coexist is acknowledged as a better alternative since it could be coordinated with other policies (Wise, 1989).

The conceptual framework below illustrates how the functional and structural aspects of reorganization are connected to network effectiveness. It also demonstrates the linkage between function and structure which affects mechanisms of network integration.

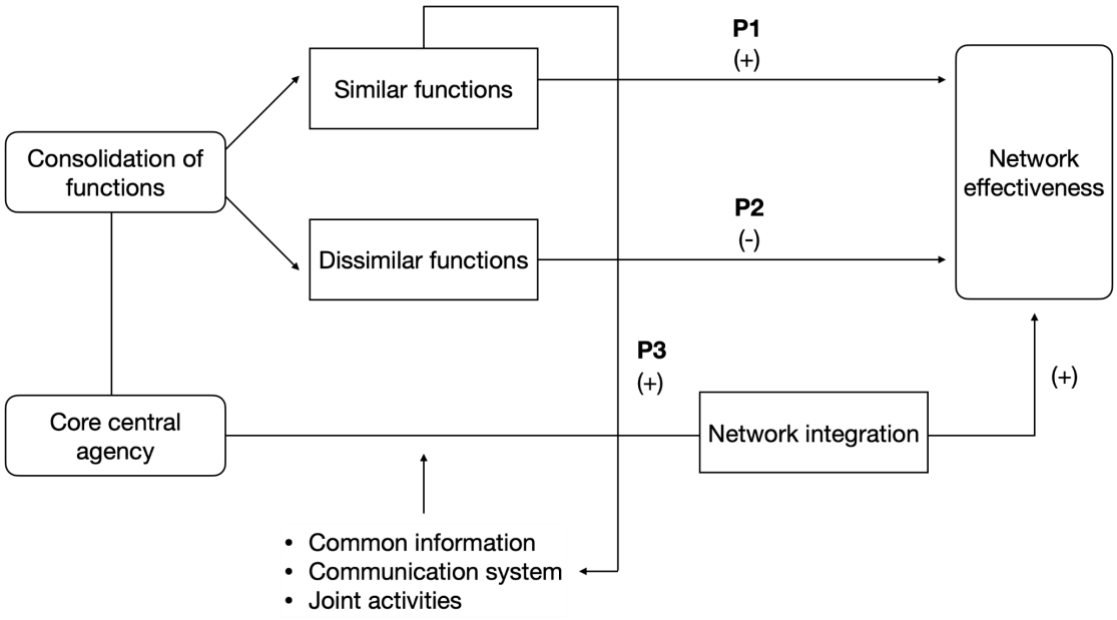


Figure 25. Conceptual Framework and Propositions

Based on the conceptual framework, following propositions are derived to answer the research question:

- Proposition 1 (P1): Reorganization by consolidating similar functions is likely to have a positive impact on network effectiveness
- Proposition 2 (P2): Reorganization by consolidating dissimilar functions is likely to have a negative impact on network effectiveness
- Proposition 3 (P3): Incorporating similar functions into a core central agency enhances the share of common information, communication systems, and joint activities, which serve as mechanisms of network integration

6.2 Matching Theoretical Patterns to Empirical Patterns

In this section, each proposition based on respective theories will be matched with empirical patterns. First, the empirical patterns of interactions of government organizations observed from government reports will be identified, revealing the link between functional consolidations and network effectiveness. Then, empirical patterns derived from semi-structured interviews will be analyzed to explore the connection from functional consolidation to network effectiveness. These results will be combined and summarized in the last subsection generating a comprehensive account of the whole.

Before identifying empirical patterns as observed from the Gyeongju and Pohang Earthquakes, some organizational backgrounds need to be clarified. First, the MPSS and MIS, which served, respectively, as the control centers in the Gyeongju and Pohang earthquakes, had distinct compositions of functions. The MPSS was composed of NEMA, KCG, VTS, and safety functions from the MSPA, incorporating similar functions into a single organization. In contrast, the MIS, from its creation in 2008 consisted of interior, civil service, emergency planning functions etc. a blend of somewhat dissimilar functions. Whereas the MPSS was newly established after experiencing the *Sewol* ferry disaster, the MIS was a return to the prior form of the organization when the new President took office.[35] The common feature across the two agencies was the position that they took within the network of disaster management system. Both organizations served as the core central agency in a response network through which other organizations interacted.

[35] See Chapter 2 for more detail on history of organizations.

6.2.1 Empirical Patterns (1): Linking Consolidation of Functions to Network Effectiveness

To draw out the relationship between reorganization and network effectiveness, the measures of effectiveness should first be determined. The concept of effectiveness is distinguishable from its common use since network effectiveness requires a more comprehensive aspect rather than measuring outcomes with limited indicators. Thus, network effectiveness is analyzed through both structural and procedural approaches, and measurements at various levels of network. As descriptive results of network analysis had shown in Chapter 5, all three levels of network - whole network, sub-network, node levels - affect the network. Based on literature cited below, the measurements of network effectiveness will be determined and used to uncover empirical patterns.

First, network level effectiveness is measured by centralization. According to Provan and Milward (1995) both density and centralization are related to network integration but the difference between the two is that while density indicates overall existence of connection, the centralization demonstrates the degree of cohesion around focal points. Moreover, the centralization measure was considered more relevant to analyze the networks of government organizations in which power and authority are asymmetrically distributed (Provan and Kenis, 2008).

Second, at the sub-network level, clique cohesion and clique overlap are utilized as measurements for network effectiveness. Cliques, maximal subgraphs composed of three or more nodes (Hanneman and Riddle, 2005), vary in size and have overlapping memberships. The levels of cohesion differ across cliques, indicating distinct degrees of integration within the cliques. Based on Provan and Sebastian's (1998) findings that high integration within networks

is correlated with network effectiveness, these two measures serve as indicators for network effectiveness.

Finally, at the node level two centrality measures - degree and betweenness centrality - are employed. Because in a disaster, it is critical that organizations are connected to one another in a way that accelerates response, having many links and bridging others are selected as indicators for network effectiveness. These node level centrality measures will be analyzed together with the network level centralization values since it is the basis for the concept of centralization. Unlike Chapter 5, where node level centralities of all participating organizations were analyzed, this chapter will highlight the MPSS and MIS with their adjacent nodes (neighbors) as core agencies of disaster management to focus more on how reorganization of the MPSS and MIS could be associated with network effectiveness.

6.2.1.1 Consolidation of Functions and Network Effectiveness: Effectiveness Measured by Network Centralization and Node Level Centralities

Centralization, a network level indicator for network effectiveness, was higher in the Gyeongju earthquake response network than the Pohang earthquake response network. Degree centralization, the extent of cohesion around the focal point, was 61.11% and 45.32% in the Gyeongju and Pohang earthquakes respectively. Since degree centralization is determined by the maximum degree centrality value of a focal node and degree centrality values of other nodes, it demonstrates how centralized the network is towards the major node. As expected, the organization with the highest degree centrality value in the Gyeongju case was MPSS with 0.703 and in the Pohang case it was MIS with 0.586.

To explore deeper into how consolidation of similar functions versus dissimilar functions differed in response activities, the degree centrality values of adjacent nodes to MPSS

and MIS are examined. Figure 26 and Figure 27 demonstrate the network of MPSS/MIS and its adjacent organizations who interacted in response to earthquakes. This was done by selecting MPSS/MIS and their direct neighbors in each network and then re-running the degree centrality calculation process in the *Netminer* Program. As a consequence, the isolated nodes and the nodes not directly connected to MPSS and MIS were eliminated.

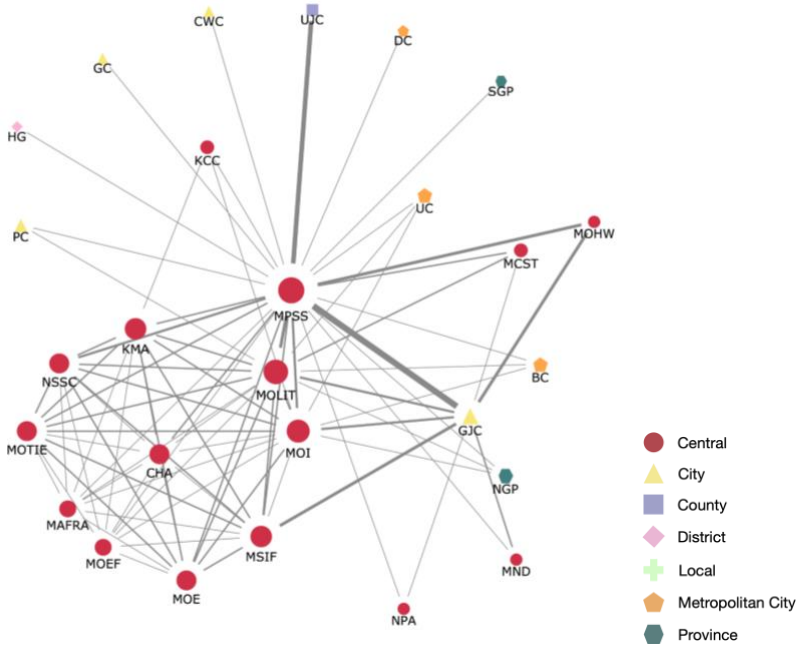


Figure 26. Network of MPSS and Its Adjacent Organizations Based on Degree Centrality

Table 17. Degree Centrality Values in the Gyeongju Earthquake

	Degree Centrality	
	Organization	Value
1	MPSS	0.703
2	MOLIT	0.432
3	MOI	0.405
4	KMA	0.297
5	MSIF	0.297
6	MOE	0.270
7	MOTIE	0.270
8	NSSC	0.270
9	CHA	0.270
10	MAFRA	0.243
11	MOEF	0.243
12	GJC	0.216
13	UC	0.081
14	BC	0.081
15	NGP	0.081
16	KCC	0.081
17	MCST	0.081
18	MND	0.054
19	NPA	0.054
20	PC	0.054
21	MOHW	0.054
22	HG	0.027
23	GC	0.027

Table 17. Degree Centrality Values in the Gyeongju Earthquake (continued)

24	CWC	0.027
25	UJC	0.027
26	DC	0.027
27	SGP	0.027

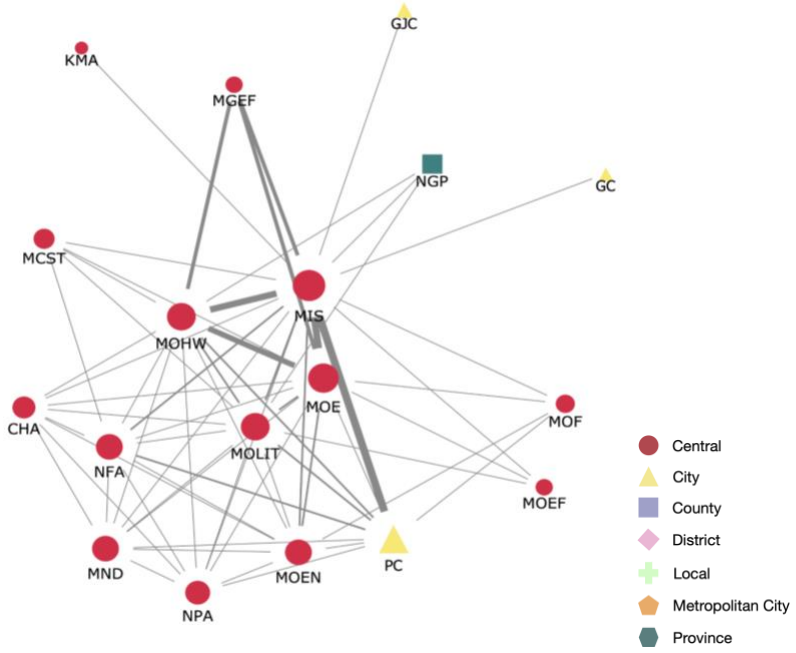


Figure 27. Network of MIS and Its Adjacent Organizations Based on Degree Centrality

Table 18. Degree Centrality Values in the Pohang Earthquake

	Organization	Value
1	MIS	0.586
2	MOE	0.448
3	PC	0.414
4	MOLIT	0.414
5	MOHW	0.414
6	MND	0.345
7	MOEN	0.345
8	NFA	0.345
9	NPA	0.310
10	CHA	0.276
11	MCST	0.172
12	NGP	0.138
13	MOF	0.138
14	MOEF	0.103
15	MGEF	0.103
16	GJC	0.069
17	KFS	0.069
18	MOJ	0.034
19	MSICT	0.034
20	NSSC	0.034
21	KMA	0.034
22	MOEL	0.034
23	GC	0.034

Acronyms	
• CHA: Cultural Heritage Administration • GC: Gumi City • GJC: Gyeongju City • KFS: Korea Forest Service • KMA: Korea Meteorological Administration • MCST: Ministry of Culture, Sports and Tourism • MGEF: Ministry of Gender Equality and Family • MIS: Ministry of the Interior and Safety • MND: Ministry of National Defense • MOE : Ministry of Education • MOF: Ministry of Oceans and Fisheries • MOEF: Ministry of Economy and Finance	• MOEL: Ministry of Employment and Labor • MOEN: Ministry of Environment • MOHW: Ministry of Health and Welfare • MOJ: Minitry of Justice • MOLIT: Ministry of Land, Infrastructure, and Transport • MSICT: Ministry of Science and ICT • NFA: National Fire Agency • NGP: North Gyeongsang Province • NPA: National Policy Agency • NSSC: Nuclear Safety and Security Commission • PC: Pohang City

It is noteworthy that in both networks, the central level agencies, represented in red circles, are tightly connected to each other. This implies that between central level agencies, the connection is generally unaffected by difference in functional forms of organizations. However, when relative importance in terms of degree centrality is considered, it showed somewhat disparate results. As the variation in sizes of nodes display, the MPSS has a greater influence in the network whereas the MIS shares its authority with other central level agencies. Moreover, the organizations having frequent interactions with the focal nodes were distinctive. Seen from frequencies of interactions marked by thickness of ties, the MPSS was closely connected to the MOHW, MOLIT, GJC, and UJC. Among these agencies and local governments, the MOHW, GJC, and UJC, in particular, were largely dependent on the MPSS with respect to connectedness.

Only the MOLIT had the degree centrality value comparable to that of the MPSS. In contrast, many of the organizations that had frequent interactions with the MIS in the Pohang earthquake – the MOHW, MOE, PC, and MGEF - had almost equivalent degree centrality to that of the MIS except MGEF.

The Ministry of Health and Welfare (MOHW) was identified as persistently having close relationships with the focal nodes. Yet, the extent to which the MOHW relied on the nodes was quite disparate. That is, while the difference in degree centrality of the MPSS and MOHW was 0.649, the difference between the MIS and MOHW was 0.172 meaning that the MOHW was more reliant on the MPSS in the Gyeongju earthquake than on the MIS in the Pohang earthquake. Such a gap corresponds to the degree centralization which was higher in the Gyeongju earthquake network. Thus, it could be inferred that the MPSS was better able to manage the network with its centralized authority in terms of connectedness.

Interactions with the local governments also revealed some similarities and discrepancies. In both networks, the local governments that were directly affected by the earthquake - Gyeongju City (GJC), Pohang City (PC), and their upper-level local government, North Gyeongsang Province (NGP) - were linked to other organizations as well as the MPSS and MIS. However, other local governments were connected to the network only through the MPSS or MIS. This implies that whatever form a focal node has, local level response engaged the local governments within the network, but the level of engagement varied according to the impact that the disaster had on the local government. An apparent discrepancy was that whereas the local governments connected to the MPSS had relatively smaller node than the MPSS, meaning greater dependence on the MPSS, those connected to the MIS had almost equal node size to the MIS, meaning they had as much connectedness within the network as the MIS.

In terms of betweenness, serving as a bridge between other two nodes in the shortest possible path, the bigger node size in figure 28 and figure 29 indicate the organizations with greater betweenness centrality. At the whole network level, the betweenness centralization was higher in the Gyeongju earthquake with the MPSS at the center. It was 31.27% for the Gyeongju earthquake and 22.62% for the Pohang earthquake. As was for the degree centrality, the node level betweenness centrality values were also more converged towards the MPSS than MIS. In other words, network effectiveness as measured by betweenness centralization was observed to be better in the network that the MPSS took the lead.

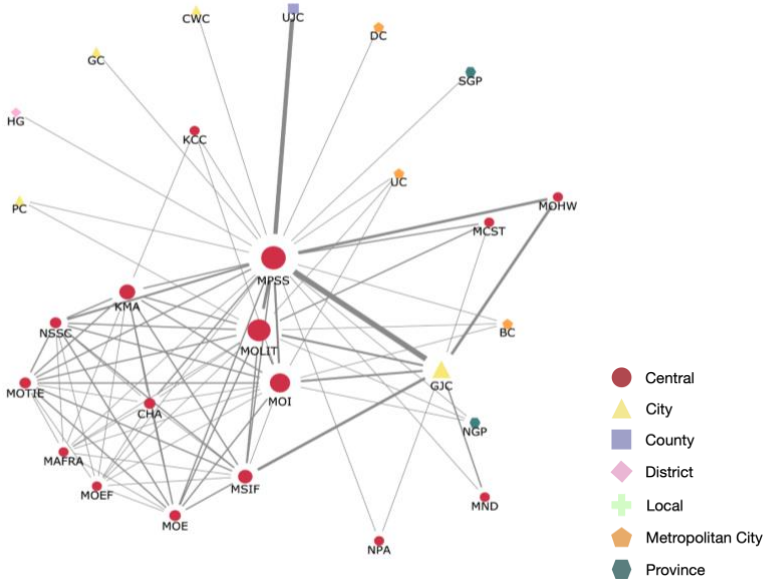


Figure 28. Network of MPSS and Its Adjacent Organizations Based on Betweenness Centrality

Table 19. Betweenness Centrality Values in the Gyeongju Earthquake

	Organization	Value
1	MPSS	0.315
2	MOLIT	0.037
3	MOI	0.025
4	KMA	0.012
5	MSIF	0.004
6	MOE	0.003

Acronyms
• KMA: Korea Meteorological Administration • MOE : Ministry of Education • MOI: Ministry of Interior • MOLIT: Ministry of Land, Infrastructure, and Transport • MPSS: Ministry of Public Safety and Security • MSIF: Ministry of Science, ICT, and Future Planning

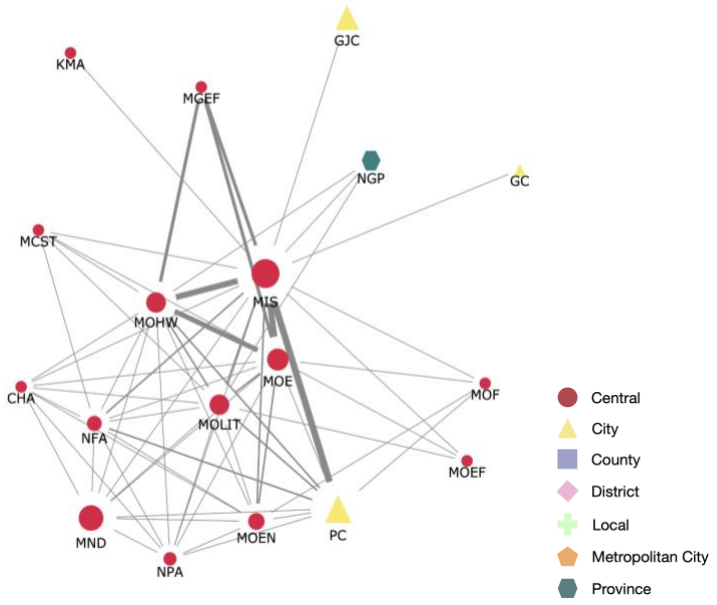


Figure 29 Network of MIS and Its Adjacent Organizations Based on Betweenness Centrality

Table 20. Betweenness Centrality Values in the Pohang Earthquake

	Organization	Value
1	MIS	0.238
2	PC	0.137
3	MND	0.053
4	GJC	0.052
5	MOE	0.034
6	MOLIT	0.026
7	MOHW	0.026
8	NGP	0.012
9	MOEN	0.006
10	NFA	0.005
11	KFS	0.002
12	NPA	0.001

Acronyms	
• GJC: Gyeongju City • KFS: Korea Forest Service • MAFRA: Ministry of Agriculture, Food and Rural Affairs • MIS: Ministry of the Interior and Safety • MND: Ministry of National Defense • MOE : Ministry of Education • MOEN: Ministry of Environment	• MOHW: Ministry of Health and Welfare • MOLIT: Ministry of Land Infrastructure and Transport • NFA: National Fire Agency • NGP: North Gyeongsang Province • NPA: National Policy Agency • PC: Pohang City

When examined more closely, betweenness centrality is more prominent in the Gyeongju earthquake network, with some organizations that contribute more strongly to linking other organizations in response to the disaster. They are the MPSS, MOLIT, and MOI, implying that many organizations need to pass through these three agencies to interact with others. It is noteworthy that there was a sizable gap between the focal node, MPSS, and the two other organizations with respect to betweenness centrality. While the betweenness centrality of the MPSS was 0.315, that of the MOLIT was 0.037 and MOI, 0.025. That is, the MPSS as the focal center not only had the greatest connection, but also served as the most influential linkage through which others were connected.

The MIS and its adjacent nodes in Pohang network also revealed a betweenness centrality that is inclined towards a few organizations. However, the difference from the Gyeongju network was that the level of betweenness centralization was lower, meaning that betweenness centrality values of the nodes were not as concentrated to the focal node, the MIS. In addition, as evident from the sizes of nodes and the number of organizations with comparable

node sizes to the MIS, the betweenness centrality values were more or less dispersed. In other words, organizations including the MOE, MOLIT, MOHW, MOEN, and MND shared the role of bridging other organizations that were placed in between their shortest paths.

As noted previously,the thickness of the ties demonstrates the frequency of the interactions. Although both networks had frequent interactions between the focal node and the local government in which the epicenter was located, the frequency of interactions between the major central agencies serving as bridges revealed distinct patterns. That is, the nodes with high betweenness centrality in the Gyeongju earthquake - the MPSS, MOLIT, and MOI - did not interact as frequently as the nodes with high betweenness centrality in the Pohang earthquake - the MIS, MOHW, and MOE. In other words, whereas the bridges in the Gyeongju network including the MPSS had relatively less reliance on other bridges, the bridges in the Pohang network including the MIS were largely dependent on one another.

So far, network effectiveness measured by both degree and betweenness centralization was found to be higher in the Gyeongju earthquake network where the MPSS was controlling the disaster management system. Although not ultimate, the MPSS turned out to be better in achieving network effectiveness at least measured by the number of connections and bridging other organizations. By consolidating safety and disaster management functions within the MPSS, the organization was able to induce other organizations to recognize clearly that the point of control and coordination was the MPSS. In other words, merging of similar functions within an organization likely induced shared understanding about who to connect with and/or who played the role of linkage between organizations. This structure encouraged centralized management leading to network effectiveness.

6.2.1.2 Consolidation of Functions and Network Effectiveness: Effectiveness Measured by Clique Cohesion and Clique Overlap

Cliques vary in size having overlapping membership with different cohesion indices. Thus, key nodes appear multiple times in cliques with diverse memberships.[36] Table 21 below demonstrates the top three cliques with the highest cohesion index in the Gyeongju and Pohang earthquakes. Based on Provan and Sebastian's (1998) assertion that high integration and clique overlap is associated with network effectiveness, the level of cohesion and overlapping memberships in the networks are analyzed.

Table 21. Top 3 Cliques

	Gyeongju Earthquake		Pohang Earthquake	
	Members	Cohesion Index	Members	Cohesion Index
Clique 1	MPSS, MOLIT, MOI, MSIF, MOE, MOTIE, NSSC, KMA, CHA, MAFRA	7.368	MIS, MOE, MOLIT, MOHW, NFA, NPA, MOEN, MND, CHA	6.517
Clique 2	MPSS, MOLIT, MOI, MSIF, MOE, MOTIE, NSSC, KMA, CHA, MOEF	7.368	MIS, MOE, MOLIT, MOHW, NFA, NPA, MOEN, MND, PC	5.727
Clique 3	MPSS, MOLIT, MOI, MSIF, GJC	2.946	MIS, MOE, MOLIT, MOHW, NFA, MCST	3.692

Cohesion index is defined only for undirected graph. It is computed by [the density of internal ties (clique *a* → clique *a*) / the density of external ties (clique *a* → external nodes)].(Cyram, 2021)

[36] For the full list of cliques for each earthquake, see Chapter 5, Table 12 and Table 13.

Acronyms	
• CHA: Cultural Heritage Administration • GJC: Gyeongju City • KMA: Korea Meteorological Administration • MCST: Ministry of Culture, Sports and Tourism • MIS: Ministry of the Interior and Safety • MND: Ministry of National Defense • MOE : Ministry of Education • MOEF: Ministry of Economy and Finance • MOEN: Ministry of Environment • MOHW: Ministry of Health and Welfare • MOI: Ministry of Interior	• MOLIT: Ministry of Land, Infrastructure, and Transport • MOTIE: Ministry of Trade, Industry and Energy • MPSS: Ministry of Public Safety and Security • MSIF: Ministry of Science, ICT, and Future Planning • NFA: National Fire Agency • NPA: National Policy Agency • NSSC: Nuclear Safety and Security Commission • PC: Pohang City

While the mean clique cohesion of the whole network was higher in the Pohang earthquake (mean cohesion index: 4.12) compared to the Gyeongju earthquake (mean cohesion index: 3.83), the top 3 cliques with high cohesion index was higher in the Gyeongju earthquake (mean cohesion index: 5.89) than the Pohang earthquake (mean cohesion index: 5.31). Similar to the centralization where nodes were concentrated around the focal node, subnetwork level cliques also showed a relatively higher integration around the major cliques in the Gyeongju network. This result implies that, when measured by clique cohesion alone, it is difficult to determine which network were better in disseminating learning. Thus, depending on the point of emphasis - either the whole network or the major cliques - the interpretation on network effectiveness might vary.

Another measurement for network effectiveness at the subnetwork group level is the clique overlap. This was based on the rationale that overlapping members of the cliques disseminate learning throughout the network (Provan and Sebastian, 1998). First, the organizations that had multiple memberships across cliques were considered. Among the top 3 cliques, the number of overlapping memberships was identical with four organizations being included in all three cliques. So rather than merely looking at the number of overlapping members, it would be more meaningful to probe into who the members were and what influence they had within the network.

In the Gyeongju earthquake, the MPSS, MOLIT, MOI, and MSIF were the organizations with multiple memberships across major cliques. For the Pohang earthquake, those were the MIS, MOE, MOLIT, and MOHW. Generally, these organizations had relatively high degree and betweenness centrality. An organization common to both cases was the Ministry of Land, Infrastructure, and Transport (MOLIT). As presented in the table 22 below, the MOLIT's influence on others had decreased in the Pohang earthquake both in terms of degree and betweenness. In terms of function, the MIS had integrated the functions of the MPSS and MOI. Such consolidation of dissimilar functions - safety/disaster and internal affairs/interior - did not result in a greater influence but instead reduced the extent of influence within the network.

The organizations with overlapping clique membership distinctive to each case were the MSIF; and MOE/MOHW in Gyeongju and Pohang respectively. Both with respect to degree and betweenness, the MOE and MOHW had more impact in the Pohang network than the MSIF in the Gyeongju network. Particularly in terms of bridging other organizations, MSIF was less influential. In other words, MOE and MOHW were more likely to spread what had been learned. Apparently, no local governments were observed to have had overlapping memberships across

cliques. Though some of the city level governments such as GJC and PC had power with their high degree and betweenness, they did not appear in multiple cliques. From this it is presumed that learning is more likely to be disseminated by central level agencies than local governments.

Table 22. Comparison of Overlapping Members across Top 3 Cliques (Degree and Betweenness Centrality)

		Degree Centrality	Betweenness Centrality
Gyeongju Earthquake	MPSS	0.703	0.315
	MOLIT	0.432	0.037
	MOI	0.405	0.025
	MSIF	0.297	0.003
Pohang Earthquake	MIS	0.586	0.238
	MOE	0.448	0.034
	MOLIT	0.414	0.026
	MOHW	0.414	0.026

Acronyms
• MIS: Ministry of the Interior and Safety • MOE : Ministry of Education • MOHW: Ministry of Health and Welfare • MOI: Ministry of Interior • MOLIT: Ministry of Land, Infrastructure, and Transport • MPSS: Ministry of Public Safety and Security • MSIF: Ministry of Science, ICT, and Future Planning

Based on the results of network analysis, pattern matching between the theories and the empirical could be elicited (table 23). This is an intermediary step towards comprehensive pattern matching which will be addressed later in this chapter.

Table 23. Summary of Intermediary Pattern Matching (Network Analysis)

Theme	Theory	Counter Theory	Contrary Examples	Additional Themes and Explanations
Network level effectiveness	Degree centralization and betweenness centralization was higher in the Gyeongju earthquake with the MPSS at the center.			Local governments' dependence on the MPSS/MIS were affected by the level of the disaster in that area - areas with direct impact formed additional connections with organizations other than the MPSS/MIS.
Sub-network level effectiveness	Mean cohesion of the top 3 cliques was higher in the Gyeongju earthquake.	Mean cohesion of all the cliques was higher in the Pohang earthquake.		Depending on the point of emphasis, interpretation on which network had greater effectiveness might vary.
Node-level effectiveness	Degree & betweenness centrality of the MPSS than MIS.			Active bridges(nodes with high betweenness) in the Gyeongju earthquake(including the MPSS) had less interaction with other bridges whereas active bridges in the Pohang earthquake had more frequent interaction with other bridges.

6.2.2 Empirical Patterns (2): Linking Consolidation of Functions to Mechanisms of Network Integration

Incorporating similar functions into a core central agency was proposed to affect the information, communication systems, and joint activities that serve as mechanisms of network integration. To seek the link between the theoretical functions and the mechanisms of network integration, semi-structured interview data are analyzed. First, the interview transcripts were aggregated to employ topic modeling. Topic modeling was used as an exploratory step to overview what kinds of themes were identified. Themes in pattern matching represent "some level of patterned response or meaning within the data set" (Braun and Clarke, 2006). Because this research rests on theories that constitute propositions, primary themes are already established. Thus, the results of the topic modeling will be used to specify those themes and set directions for the interview analysis.

6.2.2.1 Identifying Themes of Patterns through Topic Modeling

The results of topic modeling are shown in the table 24 below generating ten major topics. These topics present the collective cognitions of the members within the central organization which reveals the current status of disaster management. The topics are composed of multiple keywords that are distributed and arranged in the order of higher probability to lower probability (1st keyword ~ 5th keyword).[37] To bring out specific themes from these results, keywords from topics are selected and marked. The organizations, either stated in their names

[37]The details of topic modeling are described in Chapter 3.

or in general terms, are marked red and the mechanisms, means through which they are linked are marked blue.

Table 24. Results of Topic Modeling

	1st Keyword	2nd Keyword	3rd Keyword	4th Keyword	5th Keyword
Topic 1	local government	earthquake	impact	central	support
Topic 2	safety	Ministry of the Interior and Safety	consideration	degree	citizens
Topic 3	organization	task	remark	public official	division
Topic 4	ministry	agency	related	executive	meeting
Topic 5	timing	Ministry of Public Safety and Security	Sewol(ferry)	Ministry of Interior	past
Topic 6	disaster	society	management	nature	National Emergency Management Agency
Topic 7	Ministry of the Interior and Safety	organization	Minister	communication	government
Topic 8	disaster	part	management	response	situation
Topic 9	accident	example	Fire	Coast Guard	Ministry of Land, Infrastructure and Transport
Topic 10	occasion	investigation	expertise	need	person

First, some topics indicated how central agencies were linked to each other. For instance, agencies were thought to build relationships through executive meetings (topic 4). In executive meetings, agencies share information which serves as a mechanism for network integration. The core agency like the Ministry of the Interior and Safety was related to communications of the government organizations (topic 7). Also, joint response activities were indicated. In case of an accident, the Fire (Agency), Coast Guard, and Ministry of Land Infrastructure and Transport worked together (topic 9).

Second, organizations' linkage to the public was identified. Though such linkages are not directly related to the organizational network itself, it provides an idea about what kinds of functions that the organizations had in the disaster management system. The Ministry of the Interior and Safety considered the degree of safety of the citizens (topic 2). The National Emergency Management System was associated with the society in terms of natural disaster management (topic 6). It could be inferred that these organizations connect the networks to external actors such as the citizens and society.

Third, some critical factors in response activities were highlighted. One was the timing of notifications in the *Sewol* ferry disaster, where the Ministry of Public Safety and Security interacted with the Ministry of Interior (topic 5). In addition, expertise was needed in conducting the investigations (topic 10). These findings signal what factors are required to reinforce the mechanisms of network integration that would subsequently lead to network effectiveness.

In sum, the basic themes that composed the propositions were common information, communication systems, and joint activities. These were further specified as meetings, communicative roles, and joint response activities. In addition, organizations playing the role of linkage to the public were identified. Finally, factors affecting the network such as timing

and expertise were explored. Based on these themes, interviews with the public officials within the MIS will be analyzed to match its empirical patterns with theoretical propositions.

6.2.2.2 Consolidation of Functions and Mechanisms of Network Integration: Interview Analysis

Common Information

Common information serves as a catalyst which triggers action (Argyris, 1982; Kaufmann, 1993). It was generally agreed that meetings were channels through which disaster management agencies interact with each other both in normal times and in disaster.

> *"The Safety Policy Coordination Committee, where the minister of the MIS is the chairperson, ... holds 6-7 meetings a year."* (Interviewee 1, personal communication, Nov. 27, 2019)

> *"Heads of Si/Do (levels of local governments) Disaster and Safety Office have about 5 meetings a year … Basically, the local governments and central agencies interact with each other through meetings."* (Interviewee 1, personal communication, Nov. 27, 2019)

> *"We have a Safety Inspection Council. So the participating organizations of the council have more intimate relationships. There are two regular meetings a year and we share the investigations conducted by each organization.* (Interviewee 9, personal communication, Dec. 12, 2019)

However, concerns were raised that these meetings might hamper effectiveness. When the Blue House (BH) holds a meeting engaging the President and Prime Minister, the minister of disaster management agencies might have to participate in various redundant meetings which delays response activities. This also applies to the reporting system, where too many layers of reporting were thought to defer response.

> *"When the BH intervenes, the BH and Prime Minister [engage] increasing the hierarchy, extending the reporting process and meetings. ... diminishing the hierarchy is one way of expediting early response."* (Interviewee 1, personal communication, Nov. 27, 2019)

In accordance with the proposition (P1), consolidating safety and disaster functions into a single organization was proposed to be related to effectiveness in disaster management. However, the hierarchical position determining their power and authority was considered critical particularly in gaining collaborations from other organizations.

> *"If an organization solely dealing with disaster management is to be established, it is critical that the government strongly grants power and formally promotes their hierarchical position to a higher level. Else, disaster may not be managed properly. Even more, this [promoting the level within the hierarchy] would diminish one layer of report."* (Interviewee 1, personal communication, Nov. 27, 2019)

Communication System

While information stimulated action, the communication systems provided the ground on which information could be shared. Two aspects of the communication system were identified. One was technical systems and infrastructure based on which organizations communicated with each other. The other was organizational arrangement intended to enhance interorganizational communication. An example of the former was the National Disaster Management System (NDMS) utilized by the central agencies and local governments.

> *"NDMS is basically used across the government [agencies] and local governments. Local governments report and share information through the system."* (Interviewee 4, personal communication, Dec. 11, 2019)

> *"NDMS links disaster related organizations, which makes possible rapid spread of status reports … "* (Interviewee 11, personal communication, Dec. 27, 2019)

However, the NDMS was established before the birth of the MPSS and had been utilized across two earthquake cases. This observation indicates that the key technical infrastructure had been consistently employed despite changes in organizational configurations. A distinguishable organizational effort generated by the MPSS in terms of the communication system was that the Disaster Information and Communication Division was created after recognizing communication failure as the major problem at the Sewol ferry disaster. Another measure that the MPSS took required local governments to establish Disaster Safety Offices to build cooperative relationships with the central agencies.

"Disaster Information and Communication Division was constituted after the Sewol ferry disaster with the establishment of the MPSS. This was a small organizational change. … After such offices were created, communication tasks on disaster and safety were launched and information systems came to be managed comprehensively." (Interviewee 2, personal communication, Dec. 3, 2019)

"Disaster Safety Offices were formed within local governments at the time of MPSS. The reason was that since we [central and local] had weak cohesion, positioning the head of the Disaster Safety Office at local governments was thought to [enhance cohesion]. Now it is obligated to create the Disaster Safety Offices." (Interviewee 3, personal communication, Dec. 5, 2019)

One direct and noticeable impact of consolidating disaster management functions within the MPSS was that communication between specific functions had been enhanced. The MPSS, incorporating the National Emergency Management Agency and the Korea Coast Guard, was assessed to be better in terms of communicating emergency functions between land and coastal areas. This was another reaction to the Sewol ferry disaster in which a disconnection had been noticed between emergency functions.

"The Central Fire Services and the Coast Guard were within the same organization. So discussions were facilitated between them. [Before the reorganization] it was often the case that agencies handed over their responsibilities to other agencies. If a fire

occurred in ships, it was debated whether the NEMA should be activated since it was fire, or the Coast Guard should be activated since the fire occurred in ships. However [after these functions were consolidated within] the MPSS, such problems did not ensue." (Interviewee 5, personal communication, Dec. 11, 2019)

In sum, the affirmative nature of communication identified in the MPSS was largely attributable to the organizational rearrangement after experiencing the Sewol disaster. The technical infrastructure that facilitated communication system such as NDMS and Disaster and Safety Communications Network, either had existed before the MPSS or had been developed after the MPSS were disbanded. This implies that whereas the communication system was strengthened by means of organizational reconfiguration, it would be difficult to conclude that technical infrastructure had also been developed as a consequence of such a reorganization.

Joint Activities

Joint activities among the participating organizations were observed through the accounts on settings where multiple organizations jointly acted to manage disasters. As for the communication system, creating committees, offices, and divisions were distinctive to the MPSS in coordinating joint activities.

"With the MPSS, Safety Policy Coordination Committee was instituted and operated, which intensified the general coordination function. … the roles and responsibilities had also been increased with the enhanced coordinating function." (Interviewee 6, personal communication, Dec. 11, 2019)

"Complex disasters [incorporating] natural disaster and social disasters engaged multiple organizations … so there was a demand for a controlling organization that could take charge of general coordination. Consequently, the Special Disaster Office was constituted within the MPSS. Then president Geunhye Park stated that these 12 disasters were not unique tasks of the Ministry of Security and Public Administration (the former agency of the MPSS), but they did require a general coordinating role. … and this triggered the establishment of the Special Disaster Office." (Interviewee 9, personal communication, Dec. 12, 2019)

Some of the interviewees' remarks were parallel to the proposition that suggested incorporating similar functions into a core agency would intensify joint activities. Such remarks were either stated directly by referring to the MPSS or by describing such organizational features.

"Viewing from a bigger framework, a weakness of the MIS is that it does not prioritize safety tasks. [In contrast] the tasks of the MPSS are solely on safety." (Interviewee 11, personal communication, Dec. 27, 2019)

"With respect to decision making in disaster management, an agency takes action according to the command and control of its minister. … this is in fact how the organizational system operates in normality. … In this perspective, there should be an organization that is dedicated [to the safety tasks]. By being dedicated to disaster and

safety, the organizational capacity could be enlarged. This affects the capability of the members and their sense of duty." (Interviewee 3, personal communication, Dec. 4, 2019)

In contrast, accounts that conflicted with the proposition were also noted. Although the Disaster Management Support Group had been instituted in the Gyeongju earthquake when the MPSS coordinated the disaster, actual activation took place at the Pohang earthquake by the MIS. Moreover, some argued that, although the MPSS played a leading role in disaster management, other ministers and agencies tended to impose disaster related tasks on the MPSS. This situation improved later with the MIS at the center of the disaster management system. Another strength of the MIS was that it had good connections with the local governments. Thus, monitoring and supporting the local scene was considered better.

"The Disaster Management Support Group was activated in the Pohang earthquake [by the MIS]." (Interviewee 1, personal communication, Nov. 27, 2019)

"The MPSS took the lead in disasters, other agencies and ministers handed over the disaster [management roles] to the MPSS. ... Now with the MIS, it is relatively well established in terms of assigning respective roles." (Interviewee 5, personal communication, Dec. 11, 2019)

"The role of the MIS [in disaster response] is ... it has good connections to the local governments, where continuous action takes place. Through the Pan-government

Countermeasures Support Headquarter, the MIS monitors and supports the local scene." (Interviewee 4, personal communication, Dec. 11, 2019)

As seen in the MPSS' response to the MERS outbreak in 2015, establishing organizations was not sufficient to induce collaboration in the disaster management system. Thus, further explanations are needed to support or reject propositions. In the next section, additional themes and explanations, identified from the aforementioned themes, will be described in relation to the propositions.

Additional Themes and Explanations

The mechanisms of network integration were indeed affected by the structures of the core organization in one way or another. However, a few additional themes and explanations were observed that have been associated with the propositions. These themes are classified into power and resource, experience of disaster, tension between expertise and coordination.

Power and Resource. Plenty of observations were made on how power had influenced the way disaster management system operated. Particularly in terms of general coordination, power was considered critical. When NEMA took control of natural hazard events, it was difficult to draw out cooperation from other organizations with its limited power. Thus, when the MPSS was created, the power had been authorized by law. But still, in an administrative command system with a strict hierarchy, it was difficult for the minister of the MPSS to command other ministers.

"The most important thing for a general coordinator is power. … NEMA, which previously had responsibility over natural disasters, had difficulty in urging others. Now that it is incorporated [as an independent external agency of the MIS], it is relatively better." (Interviewee 5, personal communication, Dec. 11, 2019)

"In fact, the core disaster management agency needs to spur other organizations. But as a lower level agency ('Cheong'), it is hard to control higher level agencies ('Bu'). … In the case of the MOE, whose minister is also a vice prime minister, the minister of the MIS is difficult to ask them what to do." (Interviewee 3, personal communication, Dec. 5, 2019)

"It was stated in the laws - Government Organization Act and Framework Act on the Management of Disaster and Safety - that the minister of the MPSS be the head of the CDSCHQ. But the reason why it didn't operate properly is because they were in a horizontal position making it difficult to induce compliance from other organizations." (Interviewee 1, personal communication, Nov. 27, 2019)

An awareness commonly reiterated by numerous interviewees was the MPSS' weak connections to the local. This was largely attributable to its lack of power to engender local support. Gaining local support is critical particularly in disaster response since local actors serve as the actual hands and feet of those who take general control over the incident. What the MPSS lacked was the human resource and authority to give either reward or penalize the local

governments when needed. At the time, the Ministry of Interior (MOI) was tightly linked to the locals with their authority to guide and draw out cooperation from the local governments.

> *"The MPSS was established without having networks to the local. So it had difficulty operating. … The reason why the MPSS could not manage the locals was that they didn't dispatch any human resources nor had capacity to give reward/penalty to them. In contrast, the MIS has such power and authority including the right to audit and conduct investigation."* (Interviewee 1, personal communication, Nov. 27, 2019)

> *"The right to guide and gain cooperation from the locals was at the hands of the MOI. But the MPSS had relatively weak connections with them. So the MPSS imposed the locals to create the Disaster Safety Office to strengthen the cohesion."* (Interviewee 3, personal communication, Dec. 5, 2019)

> *"In some cases meetings were held at the MPSS and then the MOI had [redundant] meetings with the same agenda. Due to such administrative inefficiency and ambiguity [of responsibilities] in disasters, and also to enhance the synergy, the organization had been rearranged to what is now the MIS."* (Interviewee 5, personal communication, Dec. 11, 2019)

> *"In the MIS, we have the Local Administration & Decentralization Office which coordinates the local governments. … and since we [disaster functions] are within the*

same organization, it is easier to stimulate cooperation." (Interviewee 6, personal communication, Dec. 11, 2019)

The power to manage response activities was closely related to specific resources an organization had. With respect to power over the local leaders, the minister of the MIS has the authority to appoint vice mayors and vice governors.[38] Moreover, the MIS allots grant tax, or the local finance subsidy, which indirectly affects the local governments. In other words, factors affecting the effectiveness of disaster management at the local level were not resources directly related to disaster function. Instead, they included power over staffing and finances critical for the continuation of local governments.

"The biggest linkage to the locals is the authority to appoint vice mayors and vice governors. … This has to be discussed with the mayor or governor in which officers of the MIS are engaged. … So they (local public officials) comply to what the minister of the MIS says" (Interviewee 7, personal communication, Dec. 11, 2019)

"The MIS has uniqueness in that it distributes grant tax (local finance subsidy) to the local governments. This does not have to do with disaster management but we are responsible for government organization. The Government Innovation and Organization Management Office is within the MIS, under the same minister [with the disaster management offices], so it indirectly impacts [local governments in

[38] This is stated in Local Autonomy Act 110(3): "The Deputy Mayors and the Vice Governors … shall be appointed by the President through the Minister of the Interior and Safety on the recommendation of the competent Mayor/Do Governor"

disasters]. We also have bureaus dealing with local fiscal policies which empower the agency to manage local governments effectively." (Interviewee 8, personal communication, Dec. 11, 2019)

"In order to bring adherence from those [organizations] that are not willing to, we need something to govern them either through budgeting or staffing. … The MPSS merely imposed responsibilities without giving authority which would influence their normal tasks such as finance and personnel." (Interviewee 10, personal communication, Dec. 12, 2019)

While power and resources are inter-organizational factors, the following theme - experience with disaster - is an external factor difficult to be control or adjust.

Experience of Disasters. By and large, several social and natural disasters occurred before and after reorganization that might account for how such unexpected incidents affected the way different forms of organization operated in disasters. Experiencing different kinds of disasters have shaped organizations to learn amid changing environments while adapting and evolving accordingly.

First, the most striking event commonly indicated by numerous interviewees was the *Sewol* ferry disaster which took place in 2014. Particularly in terms of collaboration it had a positive impact on governance. Also, experiencing the very social disaster characterized by complex intersections of various functions, the roles and responsibilities were said to be clarified at the actual implementation. The *Sewol* ferry disaster was phenomenal in that it caught

public attention on safety and triggered extensive organization and policy changes.

> *"There are some positive and some negative consequences of the Sewol ferry disaster and one of the positive effects is that collaboration, horizontal governance, has been enhanced. … Before the Sewol disaster, accidents at oceans did not draw much attention. As a result of learning, organizations came to realize what their roles were in subsequent accidents. … Without experience, it is difficult to recognize how they should respond in disasters."* (Interviewee 1, personal communication, Nov. 27, 2019)

> *"The MPSS has been generated because of the Sewol disaster. … The [public] attention and expectation on roles and responsibilities of disaster management had been heightened [after the Sewol ferry disaster]. [Thus] roles of central agencies were intensified and local level organizations had increased as well."* (Interviewee 7, personal communication, Dec. 11, 2019)

Such efforts to meet the increasing demands of the public and to adapt to the environment were applied to organizational structures as seen from the creation of the MPSS. While the MPSS served as the core central agency for disaster management, the MERS and Gyeongju earthquake ensued, providing a testbed for the newly established organization. The changes were observed in an increase in the number of related organizations. The Gyeongju earthquake, in particular, spurred the government to make systematic and comprehensive investment on earthquakes.

"In MERS, the Central Disease Control Headquarters was upgraded to be led by the MOHW. Also after the Gyeongju earthquake, divisions and researchers related to the earthquake had been increased. This had a subsequent effect on the MOLIT which reinforced earthquake tasks. … After recognizing that Korea was vulnerable to earthquakes, a lot of attention was put on earthquake policies." (Interviewee 2, personal communication, Dec. 3, 2019)

"Though the Gyeongju earthquake had marginal damage, it triggered the government to employ the most systematic and extensive investment. Accordingly, a comprehensive plan on earthquake prevention was instituted. Within the KMA, an increased number of seismographs was installed and the organization expanded as well. In the local governments, human resources in addition to the budget for building earthquake-resistant facilities had been expanded. ... The Pohang earthquake proved that the investments after the Gyeongju earthquake did not go in vain. Although the damage was larger [than the Gyeongju earthquake], the emergency alert was distributed rapidly and decisions within the central agencies were made promptly. … In fact, such investments after the Gyeongju earthquake influenced diminishing damages in the Pohang earthquake." (Interviewee 10, personal communication, Dec. 12, 2019)

Overall, organizational configuration was not critical in creating the link between the experience of disasters and effectiveness. Rather, experiences had been accumulated over time as a result of learning and adaptation. For instance, the Disaster Management Support Group was instituted before the Gyeongju earthquake but was activated during the Pohang earthquake. This was considered an instance of organizational learning after experiencing earthquakes.

> *"When a disaster occurs, we learn what to do in a certain situation and an organization evolves along the way. Having a single division solely dealing with disaster management support is quite remarkable … what kind of decision making system should be employed in case of important events during disasters is also learned [through experience]. "* (Interviewee 3, personal communication, Dec. 5, 2019)

A difference detected between the MPSS and the MIS after experiencing disaster was that whereas the MPSS focused on establishing organizations and policies, the MIS sought to apply what had already been instituted. Again, it is difficult to distinguish whether such a difference is attributable to structural configuration. As stressed by an interviewee, disaster management agencies operate based on experience. From a network perspective, organizations that had engaged in previous disasters and connected with others are likely to be more effective in response to future disasters. This observation was supported by response to an oil storage fire in Goyang on October 7, 2018, where multiple organizations, local, and private actors engaged rapidly.

Tension between Expertise vs. Coordination. One recognizable theme was the tension between expertise and coordination. Many of the interviewees agreed that each organization has its own field of expertise within the disaster management system. Thus, when a disaster occurs, every organization needs to act according to its specific roles and responsibilities.

"It is important that each part comes into its own rapidly. … But in local governments, they lack human resources and knowledge about general disasters." (Interviewee 5, personal communication, Dec. 11, 2019)

"If there is a serious fine dust (air pollution), the MOE makes decisions on whether schools should impose early dismissal or no school." (Interviewee 3, personal communication, Dec. 5, 2019)

"We need expertise in the field of disaster management. [But] we lack education or training specialized towards disaster management." (Interviewee 6, personal communication, Dec. 11, 2019)

There is also a demand for general coordinating functions. The goal of creating an integrated disaster management system was to facilitate collaboration among diverse organizations. The existence of the Central Disaster Safety Countermeasure Headquarter (CDSCHQ) specified an institutional endeavor to reach the goal.

"Before CDSCHQ was instituted, each ministry had its own countermeasure headquarters, so our role was to support them. Now the concept of integrated system is adopted and a single ministry managing the whole … In some cases, a single organization taking control might be better and in some other cases having a high level of expertise might be better" (Interviewee 8, personal communication, Dec. 11, 2019)

"Through the cooperation of related agencies, we have collected information. The thing is, we should be able to analyze them [in a broader view] as a whole" (Interviewee 2, personal communication, Dec. 3, 2019)

Both the MPSS and MIS were coordinating organizations taking general control over other disaster management agencies. Because the MPSS was established to meet explicit needs of incorporating both land and maritime safety after the *Sewol* ferry disaster, functions of the NEMA and KCG were directly consolidated. Considering the complex features of disasters, it is not feasible that all the expertise can be absorbed into one organization. The role of the core central agency should be to determine who should be involved and what they should do in a specific disaster. In this sense, the key disaster management agency is required to coordinate other organizations so that they can perform their respective expertise.

"The central agencies, local governments and other public organizations need to distinguish what they have to do and what they do not. … I think for us (MIS), it is to deal with general disasters. Different types of disasters have agencies with relevant expertise … Our role is to let them do what they can and manage them. That is what's called integrative." (Interviewee 2, personal communication, Dec. 3, 2019)

In sum, three additional themes - power and resources, recent experience of disaster, and the tension between expertise versus coordination - varied in the extent to which they could be related to theory or counter theory. Power and resources were found to be critical in

facilitating cooperation. The MIS, especially with its authority over local governments, was better than the MPSS in eliciting effectiveness as opposed to Proposition 1 & 2. No clear pattern was identified between organizational structure and how their experiences in disasters impacted effectiveness. Instead, experiences accrued with time as evidence of learning. While both expertise and coordination were critical in joint activities, the role of the core central agency was to coordinate other organizations to implement expertise in their areas. This was considered characteristic of both the MPSS and MIS, implying that no distinguishable pattern was correlated to their configurations. From the interview analysis, the theoretical and the empirical patterns were matched as summarized in the table 25.

Table 25. Summary of Intermediary Pattern Matching (Interview Analysis)

Theme	Theory	Counter Theory	Contrary Examples	Additional Themes and Explanations
Common information	An organization solely dedicated to disaster management function would be beneficial ***if*** its level has been upgraded, which diminishes the layers of report			Too many meetings delay response activities → utilizing the major nodes in the clique Blue House sits at the center of control in serious events - once they intervene, the process delayed → granting power to core agency
Communication system	MPSS created Disaster Information and Communication Division and began to build communication system Communication between the Fire and Coast Guard was enhanced MPSS obligated the local governments to create Disaster Safety Office	Disaster and Safety Communications Network[39] was developed by the MIS(though had not been implemented in the PH earthquake) - interoperable infrastructure	NDMS was commonly used in both cases Information and Communication Division existed across two earthquakes	Recent experience of disaster (ferry *Sewol*) For both functional arrangements, the role of central agency was to coordinate organizations through extensive communication system

[39] https://www.mois.go.kr/eng/sub/a03/bestPractices7/screen.do (accessed March 31, 2022)

Table 25. Summary of Intermediary Pattern Matching (Interview Analysis)(continued)

Joint activities	With the MPSS, Safety Policy Coordination Committee was established which intensified the general coordination function. Roles and responsibilities had also increased Special Disaster Office was created within the MPSS, coordinating large scale disasters that require multiple organizations to be engaged In terms of decision making, agency solely dealing with disaster is needed to enhance their capacity MPSS prioritize safety and disaster functions	In Pohang response Disaster Management Support Group was activated (which had existed before) MIS seems to be better in assigning individual roles (coordinating) MIS formed good networks with the local government where the actions are taken	Despite organizational development, collaboration system did not function well as seen in the MERS (MPSS)	Integrated system vs. Expertise Gap between the central agencies and the local in terms of expertise Either experience has augmented capacity, or structurally, the MIS is better at coordinating

Table 26. Summary of Intermediary Pattern Matching (Interview Analysis)(continued)

Additional Themes	
Power/ Resource	The Framework Act had given MPSS the authority to take overall control and coordination, but other agencies did not conform since they were at the equal levels - Although the MPSS was also a ministerial level agencylike the MIS, 'Cheo' (MPSS) is structurally lower than 'Bu (MIS)' in Korean government organization - The administrative command system makes it difficult for a minister to command other ministers MPSS had weak connections to the local governments due to lack of power and resources to engender local support - The MPSS required local governments to create the Disaster Safety Offices - In contrast, the MIS had the power to move the local governments forward. The MIS had the authority to appoint vice mayor and vice governors, and also to allot grant tax funds. - Power to manage response activities was indirectly related to resources that a central core agency had such as staffing and finances
Experience of Disaster	After experiencing the *Sewol* disaster, expectations of the public had been increased, the role of the central agencies was strengthened, which affected the local governments as well Gyeongju earthquake was the disaster that stimulated the government to make systematic and comprehensive investment - It strengthened the response capacity at the Pohang earthquake - Alert messages were distributed rapidly, decisions were made promptly, Disaster Management Support Group had been activated Experience accumulated over time through learning and adaptation rather than being mediated by organizational configuration After experiencing disasters, the MPSS focused on establishing organizations and policies while the MIS applied what had previously been instituted

Table 27. Summary of Intermediary Pattern Matching (Interview Analysis)(continued)

Coordination vs. Expertise	Need to distinguish when expertise is needed and when coordination is needed - coordination requires analysis of the larger picture Coordinating function of the core agency (MPSS & MIS) has been strengthened over time The role of the key disaster management agency is to coordinate other agencies so that they can perform their expertise

6.2.3 Comprehensive Pattern Matching

Combining the empirical results from both network and interview analysis, a comprehensive match of patterns is drawn as summarized in table 26. First, the findings from the network analysis confirmed the proposition 1 “reorganization by consolidating similar functions is likely to have a positive impact on network effectiveness” at the network and node level. Degree centralization and betweenness centralization measures as indicators for network effectiveness were both higher in the Gyeongju earthquake where the MPSS served as the core central agency. In other words, in terms of connectedness and linking other organizations, the MPSS was more effective at the network and node level.

However, different interpretations could be derived for the sub-network level where cohesion of cliques was observed. That is, the results varied when the top 3 most cohesive cliques were considered versus when all the cliques were considered. Thus, the interpretation of results should consider where the emphasis is on. Such a finding implies that with the measures of clique cohesion alone, it is difficult to derive finding on which array of functions is better in terms of learning. Thus, at least for the sub-network level, the proposition 2, “reorganization by consolidating dissimilar functions is likely to have a negative impact on network effectiveness” is contradicted.

Second, the assessment on mechanisms of network integration leading to network effectiveness were identified through interview accounts. In terms of communication systems and joint activities, incorporating similar functions into one organization, like the MPSS, was found to facilitate those mechanisms. Particularly the MPSS, by prioritizing the safety functions and creating relevant organizations, enhanced communication and joint activities. Yet, this only

partially supported the proposition 3 “incorporating similar functions into a core central agency enhances mechanisms of network integration” because some conflicting results and contrary examples were also noted. Building technological infrastructure for communication system was substantiated by the MIS. In addition, the MIS was evaluated to be better in coordinating and being connected to the local actors. In all, though some results supported the proposition, mixed results indicate that further explanations may be needed.

Third, some additional themes derived from the interviews were analyzed and compared to the theoretical patterns. Both the power/resources and experience of disaster showed mixed results. While the MPSS had the legal authority to control other disaster management agencies, they lacked power and resources to draw on local support. In contrast, the MIS was able to move forward the local actors with their resources indirectly related to response activities. After experiencing disasters, the MPSS and the MIS learned and implemented in different ways. The MPSS focused on structuring organizations, the MIS applied institutions that had existed. Both had, to some extent, positive associations with network effectiveness but organizational configuration itself was not the sole factor. Rather, it was considered that accumulated experience over time had facilitated learning, resulting in better performance. In all, the legal basis for disaster management had not changed, the implementation of assigned authority was distinctive across the cases. This was attributable to the gap between intended outcomes of the established organizations based on learning and their actual outcomes. Moreover, it was not clear whether the reorganization itself had facilitated learning. Rather, the time factor served to mediate learning, meaning that experiencing disasters had an impact on network effectiveness over time, regardless of structural differences.

Finally, there was a theme raised regarding the tension between expertise and coordination. For both the MPSS and MIS as the core central agencies in disaster management, the coordinating function was thought to be critical. This coordinating function was assessed to have strengthened over time rather than to have been related to structural features of the organizations. In other words, no theoretical pattern was matched with the additional theme on coordination and expertise.

Table 28. Summary of Comprehensive Pattern Matching

Theme		Theory	Counter Theory	Contrary Examples	Additional Themes and Explanations
Network effective-ness	Network level	Gyeongju earthquake (MPSS) higher in terms of degree and betweenness centralization			Local areas directly affected by the disaster formed their own networks - relied less on the MPSS and MIS
	Sub-network level	Top cliques were more cohesive in Gyeongju earthquake	Overall cliques were more cohesive in Pohang earthquake		Depends on the focus of interpretation
	Node level	MPSS had greater degree and betweenness centrality			Active bridges in the Pohang earthquake had more frequent interactions with each other than those in the Gyeongju earthquake

Table 28. Summary of Comprehensive Pattern Matching (continued)

Mechanisms of network integration	Common information	Consolidating similar functions would be beneficial *if* organizational level is upgraded			Excessive meetings could delay response
	Communi-cation system	MPSS established different organizations (e.g. division, office) to enhance communication MPSS was able to prioritize safety function	The MIS developed Disaster and Safety Communications Network(interoperable)	National Disaster Management System, Information and Communication Division existed in both cases	Recent experience of disaster affected communication The role of core central agencies was to coordinate others using communication system
	Joint activities	The MPSS created committee, special disaster office to coordinate multiple actors The MPSS prioritized safety and disaster, which would enhance its capacity in decision making	The MIS employed existing institutions The MIS was better in assigning individual roles (coordination) and had good connections to the local governments	The MPSS showed failure in the MERS outbreak	Expertise vs. Coordination The MIS could coordinate better either through experience or more relevant structure

Table 28. Summary of Comprehensive Pattern Matching (continued)

Additional themes	Power/ Resource	The MPSS had legal authority	The MIS had the resources to move local governments forward	The MPSS was unable to draw support from other ministerial level organizations The MPSS lacked power to draw on local support	Resources that central core agencies had - such as staffing and finances - indirectly affected response activities
	Experience of Disaster	The MPSS experienced Gyeongju earthquake stimulating the government to yield systematic and comprehensive investment The MPSS focused on structuring organizations	The MIS applied existing institutions		Experience accumulated over time through learning and adaptation rather than being affected by organizational configuration
	Expertise vs. Coordinat-ion				Coordination requires analysis of the larger picture Coordinating function has been strengthened over time The role of the key disaster management agency - coordination

The comprehensive match of patterns is summarized in table 27 illustrating the record of hits and misses of the theory to the propositions. This process helps to identify which theory fits the data (Hyde, 2000; Pearse, 2019) and to see how different theories complement one another (Hopper and Hoque, 2006; Pearse, 2019). Also differentiated in colors, Y stands for confirmation of the proposition; N stands for contradiction of the proposition; and (Y) or (N) stands for mixed results meaning the proposition is partially confirmed or contradicted.

Proposition 1 seeking the relationship between consolidation of similar functions to network effectiveness was most clearly supported at the network and node level. Yet network effectiveness seen through the sub-network level needed further information on whether the focus would be on major cliques or all the cliques. Furthermore, the power/resources and experience of disaster were identified to have been associated with both kinds of organizational structure - consolidation of similar or dissimilar functions - but in different aspects. That is, whereas the MPSS had the legal authority to induce support, the MIS was found to have more powerful resources to move local actors forward. In applying what had been learned from the prior experience of disaster, the MPSS established new organizations to reinforce future implementation. In contrast, the MIS tended to apply existing institutions in response to disasters.

Contrary examples were largely noted in reference to the proposition 2 which asserted negative relations between consolidation of dissimilar functions and network effectiveness. The results of the network analysis indicated that at the sub-network level, the Pohang response network with the MIS at the center was more cohesive when all the cliques were considered. This finding demonstrates that the spread of learning across all the groups of organizations may be more likely with the MIS which incorporated distinct functions together. The MIS had resources to

stimulate the local governments and was able to learn and adapt through experience. These counter examples demonstrated that it was difficult to confirm proposition 2.

Finally, proposition 3 that explored the association between the consolidations of similar functions with the mechanisms of network integration was partly supported. Indeed, the MPSS was able to form organizations to strengthen communication and joint activities. Also, it was noted that by prioritizing safety functions, the MPSS was able to strengthen its decision-making capacity. However, accounts were mixed when some interviewees asserted that the technical infrastructure for the communication system was developed by the MIS. Furthermore, the MIS was considered better in assigning roles and having connections to local governments in joint activities. In all, though evidence supporting proposition 3 was noted, some counter theories were also supported requiring further refinement of the proposition.

Table 29. Record of Hits and Misses of the Theory to the Propositions

Theme		Proposition 1	Proposition 2	Proposition 3
Network Effectiveness	Network level	Y		
	Sub-network level	(Y)	(N)	
	Node level	Y		
Mechanisms of Network Effectiveness	Common information			
	Communication System			(Y)
	Joint activities			(Y)
Additional themes	Power/Resource	(Y)	(N)	
	Experience of disaster	(Y)	(N)	
	Expertise vs. Coordination			
Key: Y= Confirmation of the proposition; N=Proposition contradicted; (Y) or (N) = Mixed results				

6.3 Elaboration of the Propositions

On the basis of the comprehensive match of the patterns identified through theory and empirical data, the suggested propositions are confirmed or refined. First, the proposition 1 which stated consolidating similar functions is likely to have a positive impact, would have to be specified into two different aspects. That is, when observed through the whole network and individual

organizations, this proposition is supported. However, when the groups of organizations (subnetworks) are concerned, further information is needed on whether the few major cliques with greater cohesion will be considered or all the cliques will be considered. In other words, when learning is thought to be dispersed through a few major groups, then consolidating similar functions has a positive impact on network effectiveness. That is, when learning is thought to be disseminated through all the cliques, then consolidating dissimilar functions within an organization has a positive impact on network effectiveness. Therefore, proposition 1 could be specified into two different propositions.

Proposition 1 (P1): Reorganization by consolidating similar functions is likely to have a positive impact on network effectiveness

→ P1(a): Reorganization by consolidating similar functions is likely to have a positive impact on network effectiveness seen through network and node level

→ P1(b): Reorganization by consolidating similar functions is likely to have a positive impact on network effectiveness seen through a few major cliques at the subnetwork level

Then, proposition 2 suggesting that consolidating dissimilar functions is likely to have a negative impact on network effectiveness was contradicted. As mentioned in the previous paragraph, at the subnetwork level, the cohesion of all the cliques were higher in the organization that consolidated dissimilar functions. Based on this contrary example, proposition 2 could be adjusted as the following.

Proposition 2 (P2): Reorganization by consolidating dissimilar functions is likely to have a negative impact on network effectiveness

→ P2: Reorganization by consolidating dissimilar functions is likely to have positive impact on network effectiveness seen through all the cliques at the subnetwork level

Finally, proposition 3, which states incorporating similar functions enhances mechanisms of network integration, was partially supported with mixed results. Out of the mechanisms proposed, communication system and joint activities were both in part associated with consolidation of similar functions and in part associated with consolidation of dissimilar functions. While consolidating similar functions enhanced communication system and joint activities by creating organizations and prioritizing safety functions, consolidating dissimilar functions enhanced those mechanisms through technical infrastructure and application of existing institutions. Such a result implies that there is no clear relationship between the structure and the mechanisms of network integration. However, from interview accounts, a few direct effects of integrating safety functions within a single organization were noted. Thus, proposition 3 could be narrowed with some extra conditions added.

Proposition 3 (P3): Incorporating similar functions into a core central agency enhances the share of common information, communication systems, and joint activities, which serve as mechanisms of network integration

→ P3: Incorporating similar functions into a core central agency enhances communication systems and joint activities, which serve as mechanisms of network integration, by creating organizations and prioritizing relevant functions

Out of additional themes, power/resource and experience of disaster were related to proposition 1 and proposition 2 by forming environments that might affect network effectiveness across different structures of organizations. The power given to the core central agency through legal basis alone was found to be insufficient to draw support from other organizations. This was especially true in inducing support from the locals. In addition to the legal authority, the actual resources to drive implementation was critical to move forward local actors. Thus, though the structural association with the network effectiveness was unclear, having the resources to promote others was observed in an organization with dissimilar functions. With respect to experiencing disaster, different structural forms were not associated with network effectiveness but rather, were mediated by time. In other words, learning from disaster experience accumulated with time.

In sum, proposition 1 was refined into two propositions, proposition 2 was contradicted and adjusted, proposition 3 was also refined and specified. Additional themes were incorporated within the framework revealing the impact of the environment on the relationship between structure and network effectiveness. Such a result is illustrated in figure 30.

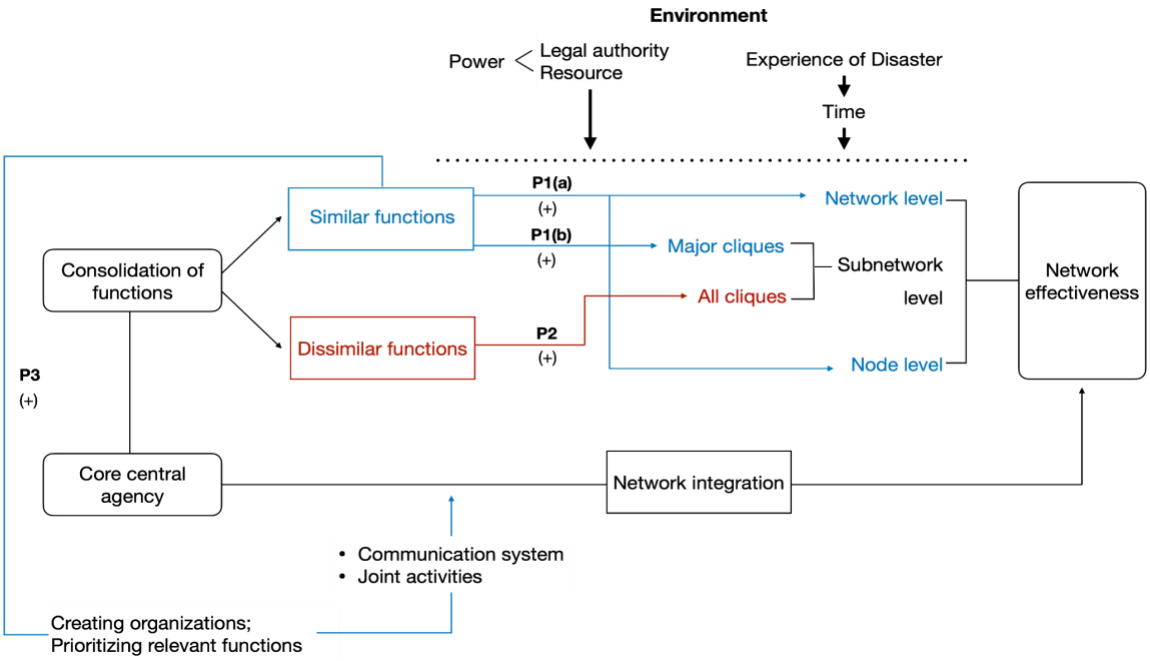


Figure 30. Elaboration of the Propositions

7.0 Evolution of Inter-Organizational Networks in Dynamic Environment

In the previous two chapters, inter-organizational networks in response to earthquakes were analyzed and compared without considering the time factor. That is, the presumed change of the networks over the course of time was not considered. Indeed, the environments were recognized and observed to have had a critical impact on the networks. However, the continuous influence of the environment and the operational context (Emerson, Nabatchi, and Balogh, 2012) were not specified as condition that could change during the process of network evolution. Thus, in this chapter, the evolution of networks during the response period - 4 weeks for each earthquake - will be analyzed.

First, the evolution of networks will be analyzed by using the network properties as employed in Chapter 5 and Chapter 6. Those properties include degree centralization and betweenness centralization at network level; community clusters at the sub-network level; degree centrality, betweenness centrality, and structural hole at the node level. The structural hole measure indicates which organizations played the role of local connections (Burt, 1992). Therefore, comparison of the key structural holes at different points in time will not only reveal which actors were critical in linking other actors but also indicate how the network had changed in terms of connecting different groups with less redundant information.

The change of relationship between organizations will be explored with respect to what kinds of interaction occurred among organizations within the network. To accomplish this, the transactions were classified into 8 categories. These transactions involve 1) the channels through which organizations interacted such as being involved in disaster and safety headquarters 2) participating in joint inspections, 3) exchanging resources 4) communicating through various

means 5) engaging in local activities 6) establishing institutions like agreements and Task Force 7) training and 8) using various information and communication systems. By exploring the kinds of interaction that occurred 4 weeks following the earthquakes, the evolution of networks and how it may have affected their effectiveness could be inferred.

Employing the time factor is consistent with the theory of fields, which suggests that change in a strategic action field potentially induces changes in other fields (Fligstein and McAdam, 2012). In fact, the reorganization of the key disaster management agency directly or indirectly affects other organizations, eventually changing the whole network. The analysis of the networks by breaking down the record of operations into different time ranges enables investigation of how the networks and the characteristics of networks differed between the two earthquake cases as each network evolved over four weeks in time. Following such a rationale, this chapter will analyze and compare the networks over time, looking into the changes in network properties and changes in types of interactions. Then, results of these analyses will be matched with the concepts used in theory of fields demonstrating the dynamics of various interdependent fields.

7.1 Evolution of Network Structure and Types of Interactions

This section will reveal how the networks have evolved in response to the two earthquakes by analyzing network properties. The network properties will be broken down into periods of four weeks, which will then be compared week by week between the Gyeongju earthquake and the Pohang earthquake. Likewise, the types of interactions will be analyzed and compared week by week, assuming they have changed over time.

7.1.1 Case Comparison of Changes in Network Structure

First, the evolution of networks was observed at the network level. Change in each network was measured by four network properties: the number of nodes (size), density, degree centralization, and betweenness centralization. The details about each measurement are illustrated in Chapter 3. Table 28 demonstrates the network level properties overtime for respective cases.

Table 30. Network Properties of Gyeongju and Pohang Earthquakes - by Week

	Network Properties	Week 1	Week 2	Week 3	Week 4
Gyeongju Earthquake	No. of Nodes (No. of isolates)	38(15)	38(18)	38(23)	38(27)
	Density	0.097	0.088	0.078	0.021
	Degree Centralization (%)	49.7	44.895	28.829	23.423
	Betweenness Centralization (%)	21.705	17.189	4.314	5.215
Pohang Earthquake	No. of Nodes (No. of isolates)	30(9)	30(18)	30(23)	30(22)
	Density	0.14	0.062	0.028	0.023
	Degree Centralization (%)	40.394	26.601	19.212	12.315
	Betweenness Centralization (%)	19.186	4.824	1.707	3.593

The size of the network as measured by the number of nodes was the same throughout the period for respective earthquakes – 38 in Gyeongju and 30 in Pohang. Therefore, it is worthwhile to look at how the number of isolates changed over time. The network size itself was bigger in the Gyeongju earthquake response (38) than the Pohang earthquake (30). However, the number of isolates, those organizations that were not connected to any other actor, was also higher in the Gyeongju network. Specifically, the percentage of isolates out of all the nodes was 30% in Pohang network, that of Gyeongju network was 39% in the first week after the earthquakes. Whereas the number of isolates steadily increased in the Gyeongju earthquake, that of Pohang increased dramatically from week 1 to week 2, then again increased from week 2 to week 3, and then fell in week 4. Such results indicate that in the Gyeongju earthquake organizations participated actively within a week after the disaster, and gradually were disconnected from the network as time went by. In contrast, in the Pohang earthquake, organizations participated to the network most ardently during the first week and then the number sharply decreased in the second week. Less than 30% of the whole remained within the network for the third and fourth weeks.

The density indicating existing links out of all the possible links for the first week was higher in the Pohang earthquake. But this measure was reversed in week 2 and week 3, as the density was higher in the Gyeongju earthquake. In week 4, both earthquakes showed a similar density. This result is in line with the percentage of isolates. Noteworthy is the time when the sharp decrease of density occurred. While the density of the Pohang network diminished sharply between week 1 and week 2, that of Gyeongju showed the steepest decrease between week 3 and week 4. Considering that the density of the Pohang network was higher than the Gyeongju earthquake in week 1, one could infer that the Pohang network engaged more organizations in the earlier stages which quickly disconnected afterwards. On the contrary, the density of the Gyeongju earthquake

showed a quite steady decrease until week 3. However, there was a steep decrease in density between week 3 and week 4, indicating that the organizations in the Gyeongju network maintained relatively longer relationships to one another compared to the Pohang network.

With respect to centralization, the extent to which the network is centralized towards the node with the highest centrality, the Gyeongju network had higher centralization throughout the whole period for both degree and betweenness. All the centralization values showed a decreasing trend but the point at which they dropped significantly differed. In the Gyeongju earthquake, the level of centralization remained quite steady till week 2 but fell dramatically from week 2 to week 3. In the Pohang earthquake, the centralization values dropped significantly from week 1 to week 2. As was noted in the density, the Pohang network appeared to have concentrated towards the major actor in the first week while the Gyeongju network remained rather centralized to the key organization until the second week.

Next, the change in clusters that formed communities over time was examined. Clusters demonstrate the subnetwork level communities that develop closer ties with some but less closer ties with others. Therefore, analyzing how the clusters changed as time went by, would provide a dynamic picture of change in fields. How the response networks for each earthquake developed clusters are illustrated is figure 31.

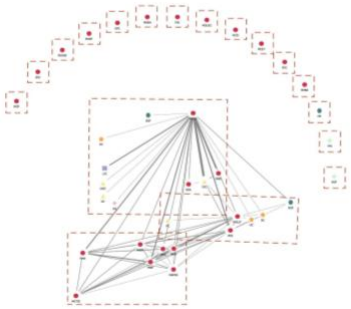
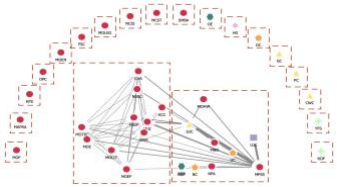
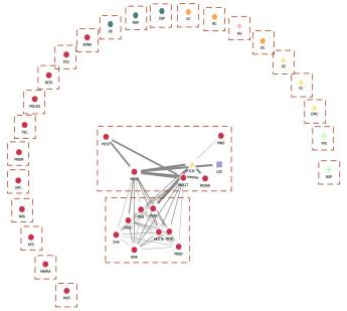
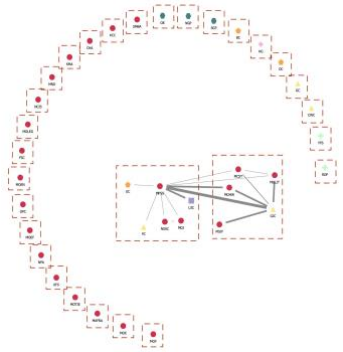
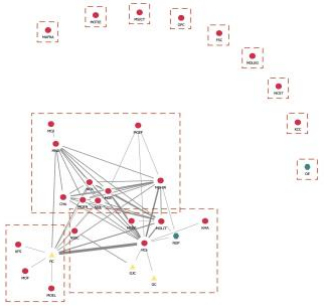
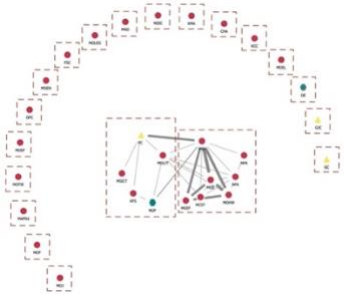
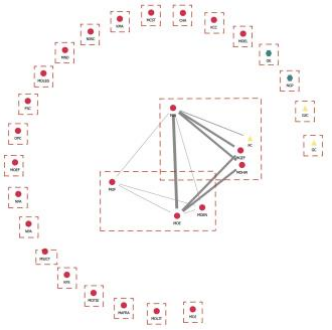
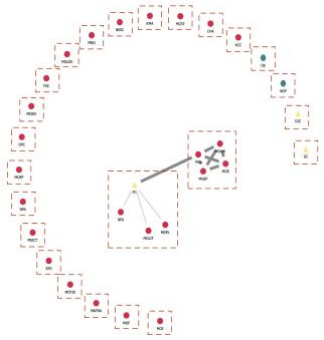
	Week 1	Week 2	Week 3	Week 4
Gyeongju Earthquake				
Pohang Earthquake				

Figure 31. Community Clusters (Modularity)

Legend:

Central City County District Local Metropolitan City Province

In the Gyeongju network, it is noticeable that the MPSS formed close ties with the local governments that otherwise would not be involved within the network. This means, if the MPSS were to be eliminated from the network, these local actors would be isolates. In addition, the MPSS and GJC were in the same cluster from week 1 to week 3, with some of their links to other clusters overlapping. Furthermore, the frequency of interaction as delineated in the thickness of the ties, tended to be higher within a cluster rather than across clusters until week 3. However, in week 4, the MPSS and GJC were involved in different clusters and thicker links were observed across clusters. Such a change indicates that interaction across communities was redundant and less frequent until week 4.

In the Pohang network, the MIS and PC formed respective clusters all the while having rather close relationships as demonstrated in the frequency of interaction. Such an observation remained consistent except in week 3, when PC was within the same cluster with the MIS. Also, in week 3, PC was not connected to other organizations except the MIS. Yet again in week 4, PC developed ties with organizations such as the NFA, MOLIT, and MOEL as well as interacting with the MIS which was in a different cluster. One could infer that from the very early phase of response the core central agency, the MIS, built relationships with other communities by being connected to a few important nodes.

A distinct characteristic between the cases was the relationship that networks established across communities. Such an inter-community interaction could be identified by investigating how the ties linking different communities developed. In the Gyeongju earthquake, it was not until week 3 that a community was linked to another community without much overlap. In other words, before week 3 the communities were linked to each other through multiple ties. Moreover, a thicker tie, denoting frequent interaction across communities, was only observable ever since week 3. In

contrast, in the Pohang earthquake, thicker ties across communities were formed relatively earlier. Although in week 1 showed rather redundant ties across three communities similar to those found in the Gyeongju earthquake, the MIS and the PC interacted frequently while involved in different clusters. Such a tendency was maintained in the Pohang earthquake throughout week 4 but with less redundant ties across communities.

Table 31. Top 10 Nodes with High Degree Centrality – by Week[40]

	Week 1		Week 2		Week 3		Week 4	
	Organiz-ation	Degree Centrality	Organiz-ation	Degree Centrality	Organiz-ation	Degree Centrality	Organiz-ation	Degree Centrality
Gyeongju Earthquake	MPSS	0.568	MPSS	0.514	MPSS	0.351	MPSS	0.243
	MOLIT	0.378	MOI	0.297	MOLIT	0.297	GJC	0.135
	MOI	0.351	KMA	0.270	MSIF	0.270	MOLIT	0.081
	MOE	0.243	MOLIT	0.270	MOI	0.270	MCST	0.081
	MSIF	0.243	MSIF	0.270	MOEF	0.243	MOHW	0.054
	MAFRA	0.243	MOEF	0.243	MOE	0.243	MOI	0.054
	MOTIE	0.243	MOE	0.243	MOTIE	0.243	NSSC	0.054
	NSSC	0.243	MOTIE	0.243	NSSC	0.243	UJC	0.027
	KMA	0.243	NSSC	0.243	KMA	0.243	MSIF	0.027
	CHA	0.243	CHA	0.243	CHA	0.243	PC	0.027

[40] The local governments are highlighted in blue.

Table 31. Top 10 Nodes with High Degree Centrality – by Week (continued)

Pohang Earthquake	MIS	0.517	MIS	0.310	MIS	0.207	MIS	0.138
	PC	0.379	MOLIT	0.241	MOE	0.172	PC	0.138
	MOE	0.379	NFA	0.207	MOHW	0.103	MOHW	0.103
	MOLIT	0.379	MOHW	0.207	MGEF	0.103	MOE	0.103
	MOHW	0.379	MOE	0.207	MOEN	0.103	MGEF	0.103
	MND	0.345	MCST	0.172	MOF	0.103	MOEL	0.034
	NPA	0.310	PC	0.138	PC	0.0345	MOLIT	0.034
	MOEN	0.310	NGP	0.103	-	-	NFA	0.034
	NFA	0.310	MGEF	0.103	-	-	-	-
	CHA	0.276	NPA	0.069	-	-	-	-

Acronyms	
• CHA: Cultural Heritage Administration • GJC: Gyeongju City • KMA: Korea Meteorological Administration • MAFRA: Ministry of Agriculture, Food and Rural Affairs • MCST: Ministry of Culture, Sports and Tourism • MGEF: Ministry of Gender Equality and Family • MIS: Ministry of the Interior and Safety • MND: Ministry of National Defense • MOE: Ministry of Education • MOEF: Ministry of Economy and Finance • MOEN: Ministry of Environment • MOHW: Ministry of Health and Welfare	• MOI: Ministry of Interior • MOLIT: Ministry of Land, Infrastructure, and Transport • MOTIE: Ministry of Trade, Industry and Energy • MPSS: Ministry of Public Safety and Security • MSIF: Ministry of Science, ICT, and Future Planning • NFA: National Fire Agency • NGP: North Gyeongsang Province • NPA: National Policy Agency • NSSC: Nuclear Safety and Security Commission • PC: Pohang City • UJC: Ulju County

The node level change in networks were measured by degree centrality, betweenness centrality, and structural holes. The changes in influential nodes over time implies the changes of focus in the response network. First, in terms of degree centrality, it is useful to identify the major organizations were that might have impacted the network in each time period (see table 29 above). The MPSS, MOLIT, MOI, MSIF, and NSSC were the organizations that were included in the top 10 organizations with high degree centrality throughout four weeks. This finding indicates that the government had put much effort in infrastructure, and especially the nuclear power plants closely related to NSSC. In week 1, MAFRA was one of the highly connected nodes but was no longer included in top 10 from week 2. The MOEF appeared from week 2 and lasted till week 3 as a highly connected organization. The MCST and the MOHW had greater degree centralities in week 4. Furthermore, the local governments such as GJC and UJC, and PC increased their connections with other organizations, showing higher degree centralities in week 4.

The Pohang response network had the MIS, PC, MOE, and MOHW as consistently influential organizations with many connections. Unlike the GJC in the Gyeongju earthquake, PC maintained its influence with its high degree centrality since the first week. Also, the MOHW was highly connected to other organizations throughout the observed period. The MND was prominent with high connectedness in week 1 but no longer from in week 2 onwards. The MGEF became highly influential in terms of degree since week 2. The MCST emerged as an impactful node in week 2. The MOEL was among the most connected organizations in week 4.

In all, network evolution in terms of node level degree centrality in the Gyeongju and Pohang earthquakes, involved some notable distinctions, such as the point at which the local governments became influential organizations. Whereas in the Gyeongju network, local governments emerged as influential in week 4, in the Pohang network, the local governments had

an impact with high degree centrality since week 1. Moreover, the MOHW which emerged as influential in week 4 in the Gyeongju network, was highly connected throughout the entire period for the Pohang network. The organizations that surfaced as an impactful in one network but not in the other were, NSSC which was consistently influential in the Gyeongju network but not in Pohang network and the MGEF which became important actor since week 2 in the Pohang network but not in the Gyeongju network.

Table 32. Top 10 Nodes with High Betweenness Centrality – by Week41

	Week 1		Week 2		Week 3		Week 4	
	Organiz-ation	Between-ness Centrality	Organiz-ation	Between-ness Centrality	Organiz-ation	Between-ness Centrality	Organiz-ation	Between-ness Centrality
Gyeongju Earthquake	MPSS	0.219	MPSS	0.172	MPSS	0.0443	MPSS	0.053
	MOLIT	0.049	MOI	0.007	GJC	0.0218	GJC	0.015
	MOI	0.017	MSIF	0.005	MOLIT	0.012	-	-
	GJC	0.005	MOLIT	0.004	MSIF	0.005	-	-
	-	-	MND	0.002	MOI	0.005	-	-
	-	-	NPA	0.002	-	-	-	-
Pohang Earthquake	MIS	0.202	MIS	0.051	MIS	0.017	PC	0.037
	PC	0.133	PC	0.034	MOE	0.005	MIS	0.030
	MND	0.048	MOLIT	0.021	-	-	-	-
	GJC	0.047	NGP	0.010	-	-	-	-
	MOE	0.021	NFA	0.005	-	-	-	-
	MOLIT	0.021	MOHW	0.002	-	-	-	-
	MOHW	0.021	MOE	0.002	-	-	-	-
	NPA	0.001	KFS	0.002	-	-	-	-
	MOEN	0.001	-	-	-	-	-	-
	NFA	0.001	-	-	-	-	-	-

[41] The local governments are highlighted in blue.

Acronyms	
• GJC: Gyeongju City • KFS: Korea Forest Service • MIS: Ministry of the Interior and Safety • MND: Ministry of National Defense • MOE: Ministry of Education • MOEN: Ministry of Environment • MOHW: Ministry of Health and Welfare • MOI: Ministry of Interior	• MOLIT: Ministry of Land, Infrastructure, and Transport • MPSS: Ministry of Public Safety and Security • MSIF: Ministry of Science, ICT, and Future Planning • NFA: National Fire Agency • NGP: North Gyeongsang Province • NPA: National Policy Agency • PC: Pohang City

Next, betweenness centrality was another indicator to investigate the change in networks at the node level (see table 30 above). In the Gyeongju earthquake, the MPSS, MOLIT, MOI, and GJC served as bridges that linked other organizations within the network. Unlike the degree centrality, GJC was an important node in terms of linking other organizations (betweenness centrality) from week 1. The MSIF and MND appeared as influential bridges in week 2. In week 4 the number of organizations linking other organizations in the shortest possible way dropped dramatically with only the MPSS and GJC taking the role as bridges.

In the Pohang network, the MIS, PC, and MOE maintained their roles as bridges almost throughout the period. The GJC as well as NGP, the province in which PC and GJC are located, played critical roles in linking other actors. The MND served as a critical bridge in week 1 but no longer in the weeks that followed. KFS emerged and took the bridging role in week 2. In week 3 and week 4, only two organizations served as bridges within the network: the MIS and MOE in week 3; the MIS and PC in week 4.

Basically, the tendency of having a few important bridges over the entire period followed by a significant decrease in the number of bridges in the later period was common to both earthquake networks. Such a dramatic fall in the number of bridges as well as their betweenness centrality value indicates that the network had been loosened towards the later period, no longer needing many bridges.

Out of various indicators measuring structural holes, efficiency was used to investigate which organizations served as the major points through which other organizations interacted with less redundant links. As shown in table 31, the mean efficiency of both the Gyeongju and Pohang earthquakes diminished over time. Moreover, the time period that showed the greatest rate of change in mean efficiency was between week 2 to week 3 for both of the earthquakes. These results imply that the efficiency of the network was relatively higher within the first two weeks after the response network had been formed. However, average values may lose information about which actors took the role of maintaining efficiency of the network. Thus, for a more detailed analysis, the nodes that served as structural holes with greater efficiency in forming ties need a closer look.

Table 33. Distribution of Efficiency (Structural Hole)

		Week 1	Week 2	Week 3	Week 4
Gyeongju Earthquake	Mean	0.371	0.362	0.214	0.225
	S.D.	0.372	0.379	0.297	0.371
	Min.	0	0	0	0
	Max.	1	1	1	1
Pohang Earthquake	Mean	0.474	0.261	0.131	0.188
	S.D.	0.378	0.347	0.255	0.35
	Min.	0	0	0	0
	Max.	1	1	1	1

Figure 32 below depicts the change of networks over the 4-week period highlighting the structural holes. That is, the organizations with greater efficiency show bigger node sizes. The structural holes are efficient nodes because they have less redundant linkages. But it is also important to understand how the structural holes are linked to others which explains their contribution to the network by enhancing efficiency. Efficiency is particularly important in disaster situations when rapid action is necessary since it determines how the network operates without overlapping ties that might delay the time.[42]

[42] For full list of efficiency values by week, see Appendix

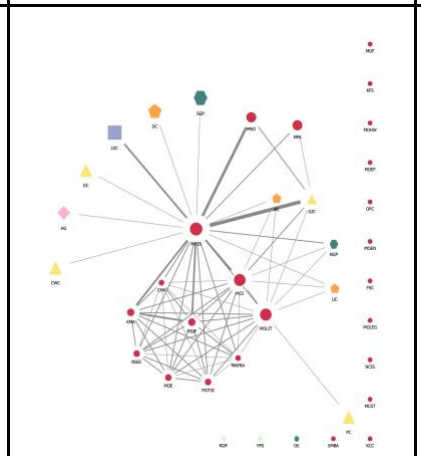
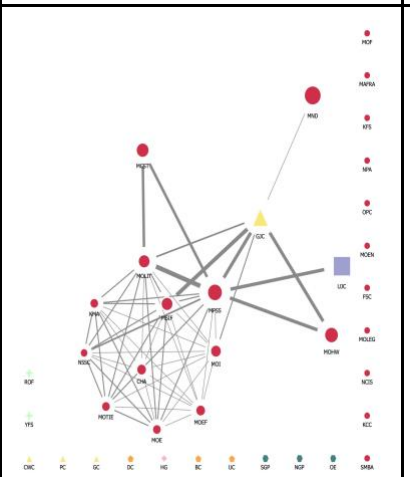
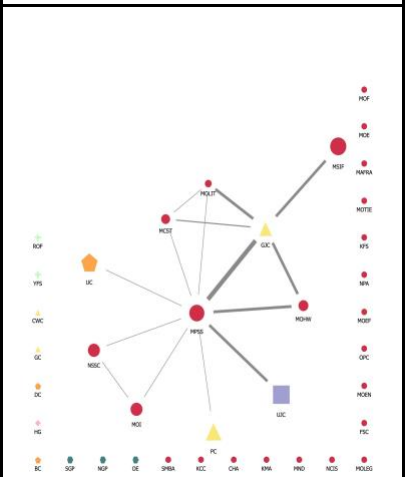
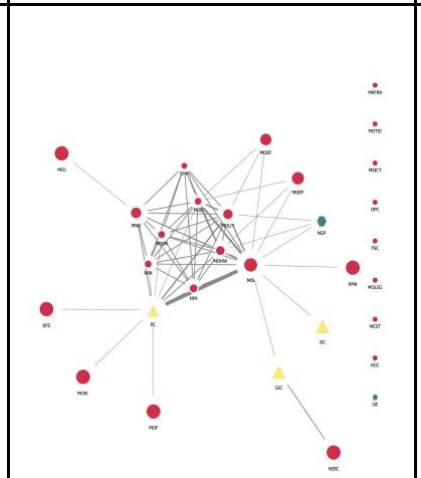
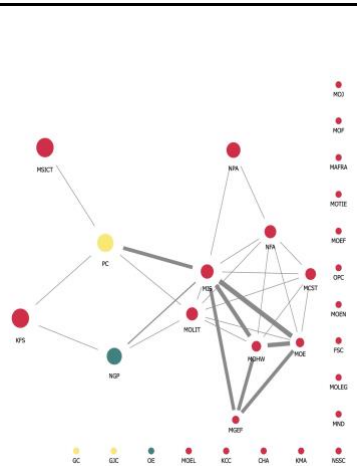
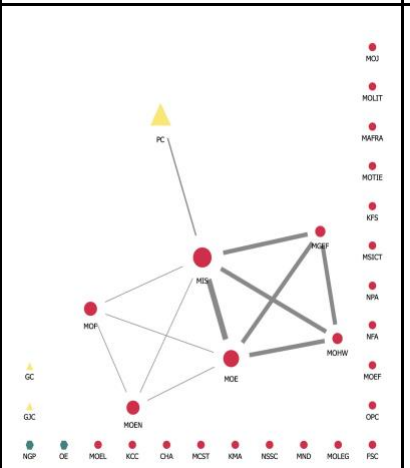
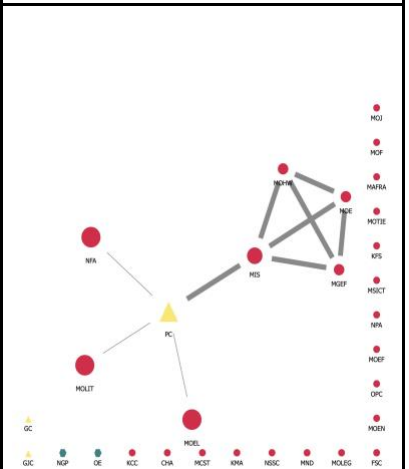
	Week 1	Week 2	Week 3	Week 4
Gyeongju Earthquake				
Pohang Earthquake				

Figure 32. Network Graphs of Structural Holes (Measured by Efficiency)[43]

Legend: Central City County District Local Metropolitan City Province

[43] The nodes with bigger node sizes demonstrate structural holes with greater efficiency (less redundant links).

Some organizations that had an efficiency value of 1 (i.e. maximum value) but were only connected to one other node, were excluded from analysis. Such nodes had no redundancy and likely had little impact since they were connected to only one node, instead of being linked to multiple nodes. In the Gyeongju earthquake, the MPSS, MOLIT, and GJC were the organizations with high efficiency throughout four weeks. The MOI was also observed to have impact as a major structural hole in week 1, 2, and 4. The MOHW and MCST emerged as efficient nodes in week 3 and week 4. The MSIF surfaced as an efficient structural hole in week 2 and week 3. Apparently, the NPA and MND had high efficiency in week 1 and NSSC in week 4. In the Pohang earthquake, the MIS, PC, MGEF, and MOHW maintained important roles as structural holes that could have affected rapid response throughout the period. The NGP and MOLIT were observed to have been efficient during week 1 and week 2. Then, the MOE became a prominent structural hole in week 3 and week 4.

When the two earthquake cases are compared, it is evident that the core central agencies for each earthquake- the MPSS and MIS - and the city level local governments - GJC and PH - had consistently served as key structural holes contributing to efficiency. The organizations unique to each earthquake that had maintained high efficiency throughout four weeks were the MOLIT and MOI in Gyeongju; and the MOHW and MGEF in Pohang. It is noteworthy that MOI was later consolidated with the safety functions of the MPSS in establishing the MIS. Whereas MOLIT, managing land and infrastructure served as an important structural hole in the Gyeongju network, the MOHW and MGEF, responsible for health, welfare; and gender, equality and family respectively played the role of linking other organizations efficiently in the Pohang network. It was also observed that the MOLIT was a major structural hole in the first two weeks of response in the Pohang earthquake while it took the role throughout the entire four weeks in the Gyeongju

earthquake. Inversely, the MOHW, a key structural hole in the Pohang earthquake in most weeks, emerged and took the role in week 3 and week 4 in the Gyeongju earthquake. For both earthquakes, the MND and NPA appeared as important structural holes early in the response period, either in week 1 or week 2.

In sum, in both networks, the local governments affected by the earthquakes acted as structural holes along with the core central disaster management agencies. Figure 33 illustrates which agencies served as the major structural holes were over the 4-week period. Moreover, organizations like MND and NPA that could mobilize initial human resources served as structural holes during the earlier response period. There were a few distinctions between the two cases. While the Gyeongju network had the ministry managing land, infrastructure, and transportation as the key structural hole throughout the observed period, the Pohang network had agencies dealing with health, welfare, and family for the entire period. This demonstrates the change that occurred between the disasters. It was also interesting to note that the MOI which took the internal affairs function also contributed to the network with its high efficiency and was later incorporated into the MIS. This action questions whether consolidating two nodes with high efficiency into one node might be more efficient for the network as a whole.

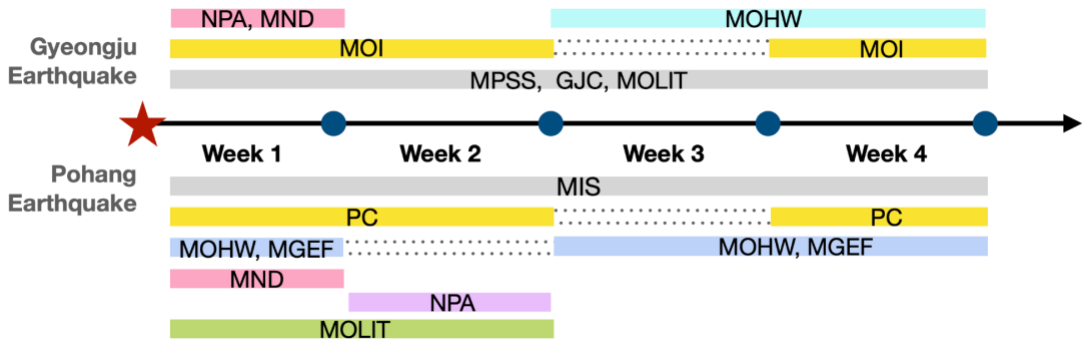


Figure 33. Comparison of Major Structural Holes over Four Weeks

Acronyms
• GJC: Gyeongju City • MGEF: Ministry of Gender Equality and Family • MIS: Ministry of the Interior and Safety • MND: Ministry of National Defense • MOHW: Ministry of Health and Welfare • MOI: Ministry of Interior • MOLIT: Ministry of Land, Infrastructure, and Transport • MPSS: Ministry of Public Safety and Security • NPA: National Policy Agency • PC: Pohang City

7.1.2 Case Comparison of Changes in Types of Interactions

Analyzing the kinds of interactions within a certain period of time was another way to view the evolution of response networks. Changes in fields occur when there are resource dependencies among actors (Fligstein and McAdam, 2012). Different types of interactions account for various ways through which diverse resources are shared. To explore how the change in types of interactions over time reflected network evolution, the frequencies of types of interactions by week were analyzed for each earthquake and then compared across the two cases. Then, the specific tasks on which one organization interacted with which other organization through what kinds of transactions are probed.

Figure 34 and figure 35 below feature the frequencies of interactions by type for four weeks following the earthquakes. The types of interactions were classified into 8 categories, which had 13 subtypes. Thus, each bar represents the types and when different subtypes were observed within

each type, they were marked in distinct colors. The numbers in each bar are the weights or frequencies of interactions for that specific type.

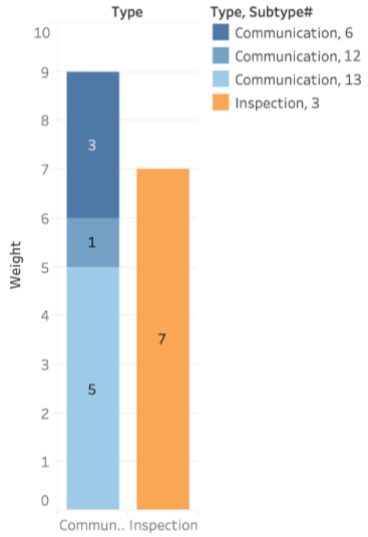
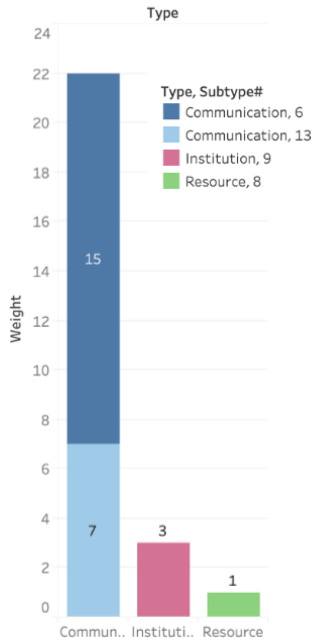
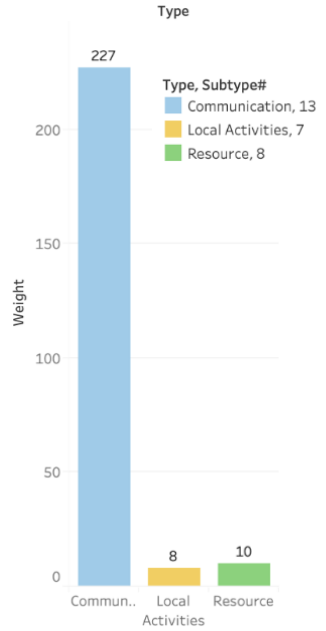
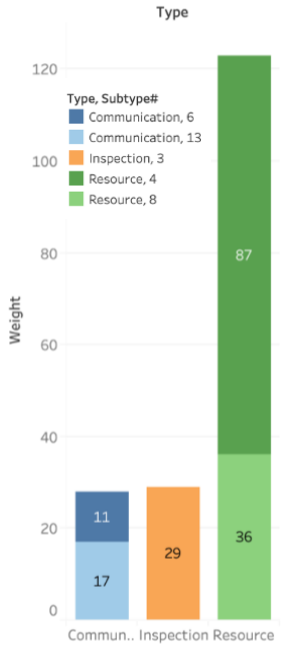
	Week 1	Week 2	Week 3	Week 4
Gyeongju Earthquake				

Figure 34. Frequency of Interactions by Type[44] - Gyeongju Earthquake

[44] Tableau 2020.3.0 was used for this graph visualization. The colors demonstrate details about type and the subtype of type of interaction.

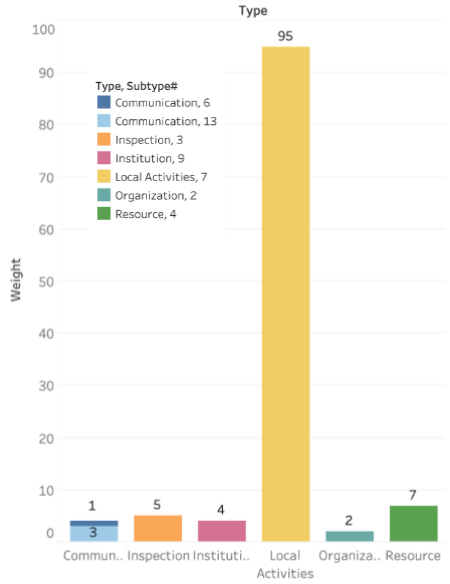
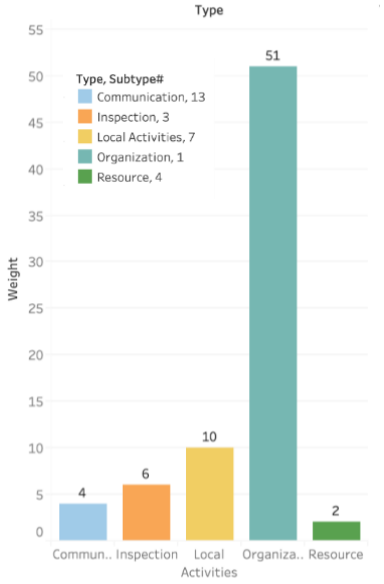
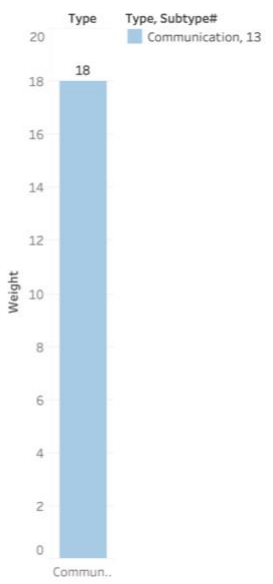
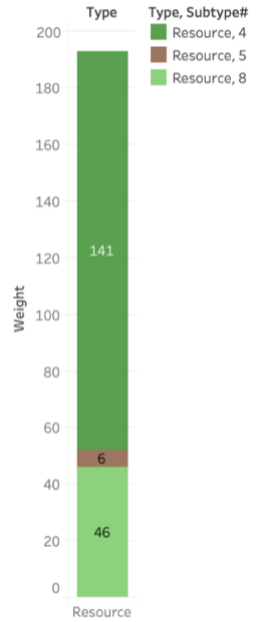
	Week 1	Week 2	Week 3	Week 4
Pohang Earthquake				

Figure 35. Frequency of Interactions by Type - Pohang Earthquake

In the Gyeongju earthquake, communication was the dominant type of interaction till week 3. Particularly in week 3, communication counted for 227 out of 245 number of interactions among organizations in the network. Meanwhile inspection was the primary way in which organizations interacted with others in week 1 and week 4. In week 2, institution and resource emerged as new types of interactions that had not been observed before. Institution includes agreements among actors to enhance response or forming task force teams to deal flexibly with changing situations. In week 3, local activities and resources were channels and means through which organizations interacted with one another yet, communication still was the dominant type of interaction. From these observations, one could infer that communication rapidly sets forth the basis for other types of interactions to take place and institutions are established to make decisions flexibly. Subsequently, types of interactions that are likely to be observed at local level emerge, such as local activities and resources. When response operations reached week 4, the ratio was reversed and resource became the dominant type. Specifically, the resource category was divided into financial resources and human resources, where the number of interactions through human resources was 87 and financial resources, 36. Based on such results, human resources appeared as an important means of interaction relatively later in the observed period.

In the Pohang network, diverse types of interactions were detected in the earlier phases - week 1 and week 2. Apparently, local activities were the most prevalent means of interaction in the first week, outnumbering frequencies of all other types combined. Unlike the Gyeongju network, in which communication and inspection were the major types of interaction in week 1, these two types took represented a relatively marginal share of interactions in the Pohang network. However, the total frequency of interactions was quite small for the Gyeongju earthquake in week 1 (16) compared to that of Pohang in week 1 (117). Institution and resources emerged in week 1,

a week earlier than in the Gyeongju network. In week 2, organization was the key channel through which actors interacted. Here, the organization stands for Central and Local Disaster Safety Countermeasures Headquarters which operates under certain conditions of large-scale disasters as stated by the law. Local activities, inspection, and communication followed organization in frequency, but organization still represented approximately 70% of the entire frequency. In week 3 the interactions were entirely through communication, but the frequency of interactions in week 3 was rather low (18). Similarly in week 4, the interactions were wholly through resources. Human resources took more than 70% of the interactions in week 4, followed by financial resources and all other types of resources.

In comparison, while communication was the major means of interaction in the first three weeks after the Gyeongju earthquake, communications were mostly concentrated in week 3 in the Pohang network. Also, there were predominant types of interaction for each week in the Pohang network. Another difference was that whereas institution and resource appeared earlier in week 1 in the Pohang earthquake, those types of transactions appeared in week 2 onwards in the Gyeongju earthquake. Seen through the total number of frequencies each week, the Gyeongju earthquake saw a significant increase in the number of interactions from week 2 to week 3. In contrast, the Pohang earthquake induced active interactions in the earlier phases - week 1 and week 2 - and then showed a sudden decrease of interactions from week 2 to week 3. Common to both networks - resource was the predominant type of interaction in week 4. When analyzed further by subtypes, ties through human resources represented the largest portion followed by the financial support.

Now that the types of interaction over the weeks following the earthquakes are analyzed, it is relevant to determine which organizations interacted with which other organizations through those means. In week 1 of Gyeongju, both communication and inspection were spread throughout

various organizations without being concentrated on a few actors. In week 2, communication became comparably more active than the previous week. Whereas the MPSS interacted with others through inspection in week 1, it actively interacted with others through communication in week 2. Those organizations that communicated most frequently with the MPSS in week 2 were, MND, NGP, and NPA. The interactions through institutions were limited to a few organizations: between KCC and KMA, MOI and KCC, MPSS and KCC.

In week 3, communication emerged as the most prevalent means throughout a wide variety of organizations. Particularly, the organizations that communicated most actively with various other organizations were the MOE, MOEF, MPSS, MSIF, CHA, KMA, and NSSC. Most of these organizations had high frequency, meaning they communicated with other organizations multiple times in week 3. The local activities and resources were used to interact with the GJC, the local government directly affected by the Gyeongju earthquake. This implies that in relation to the local response, the MND and MOI that interacted actively with GJC, played a major role.

In week 4, the frequency of communication substantially decreased with the MPSS having intense communications with the MOI and NSSC. The MOI also had focused communications with the NSSC. While the inspection in week 1 engaged the MPSS and MOLIT with various local governments, in week 4 inspection activities only involved the MOLIT, MPSS, and MCST. Exchange of resources in week 4 involved GJC, the local government, and central agencies including MCST, MOHW, MOLIT, MPSS, and MSIF. Out of those central agencies that frequently interacted with GJC, the MPSS, MSIF, and MOHW had the most intense connection through resource exchanges. The MPS, particularly, actively exchanged resources with the MOHW and UJC. Except for the interaction between the MPSS and MOHW, all other interactions were between central agencies and local governments.

In week 1 of the Pohang earthquake, the number of types as well as the overall frequency of interactions were relatively higher compared to week 1 of the Gyeongju earthquake. While communication, inspection, institution, organization, and resource were limited to a few organizations, a wider variety of organizations participated in local activities in the first week. The CHA and MND most frequently interacted with numerous organizations in local activities denoting their importance in local activities. The resource in the first week was most intensely exchanged between the MOHW and PC. As noted earlier, the subtype of resource in this period was the human resources, revealing that health and welfare-related personnel were dispatched to the local government.

Although the types of interaction remained almost the same, the frequency of the interactions dropped from week 1 to week 2. Most noticeably, local activities had decreased dramatically, merely engaging the NPA and NFA; MIS and NPA. However, the interaction through organizational means increased in frequencies and in the number of actors involved. The interaction between the MIS and MOLIT; MOE and MOLIT; MOLIT and MOHW, particularly, occurred most often. Moreover, seen through the actors engaged in organizational measures - the Central and Local Disaster and Safety Countermeasures Headquarters - the focus had changed from central-local (week 1) to central-central (week 2).

In week 3, another significant decrease was noted in frequency. The interactions were held only through communication with the actors limited to the MIS, MOE, MOEN, and MOF. The decreasing trend of interaction was reversed in week 4, generating a more intense relationship among participating organizations. The type of interaction was solely the exchange of resources and as shown in the number of frequencies among the organizations, there were concentrated ties among a few organizations. The highest frequency of resource exchange was observed between

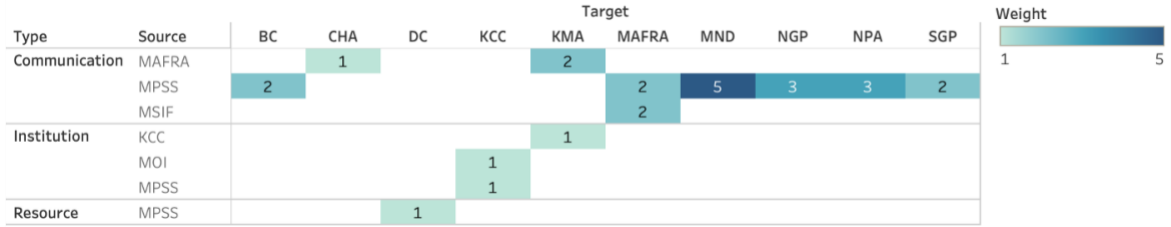
the MIS and PC, followed by MIS and MOE; MIS and MOHW; MOE and MOHW. This pattern is similar to week 4 in the Gyeongju earthquake when the MPSS had the most frequent exchange of resources with the GJC. It is noteworthy that in the Pohang earthquake, interactions of actors engaging the local governments other than PC, mostly occurred in the first week regardless of types of interactions.

When comparing the evolution of network interactions by week, the Gyeongju network revealed rather scattered ties in week 1 instead of having a few organizations with distinctively close relationships. Whereas other types of interactions engaged a limited number of actors, the local activities involved a greater number of actors with intense interactions in the Pohang network. In week 2, the MPSS in the Gyeongju network used communication while the MIS in the Pohang network mainly employed organization as a means to interact with others. In week 3, the Gyeongju and Pohang networks both had communication as the major type of interaction, but while Gyeongju network had substantially high frequency (227), the Pohang network had relatively low frequency (18). In week 4, both networks mainly had resource exchange as the means through which organizations interacted. However, while the MPSS in the Gyeongju earthquake had resource exchanges with local governments other than the GJC, the MIS was not as active in interacting with the local actors through resource exchanges in week 4.

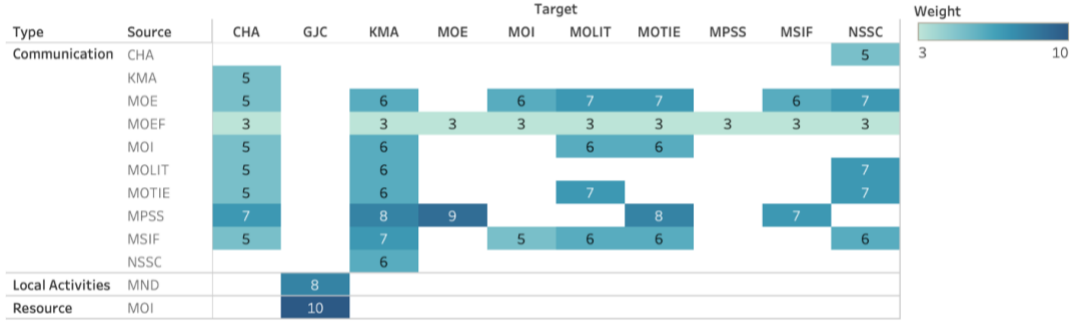
Table 34. Types of Interaction and Frequency among Organizations - Gyeongju Earthquake

< Week 1 >

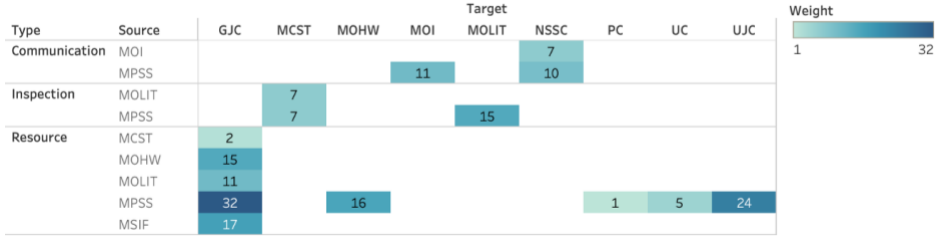
< Week 2 >



< Week 3 >



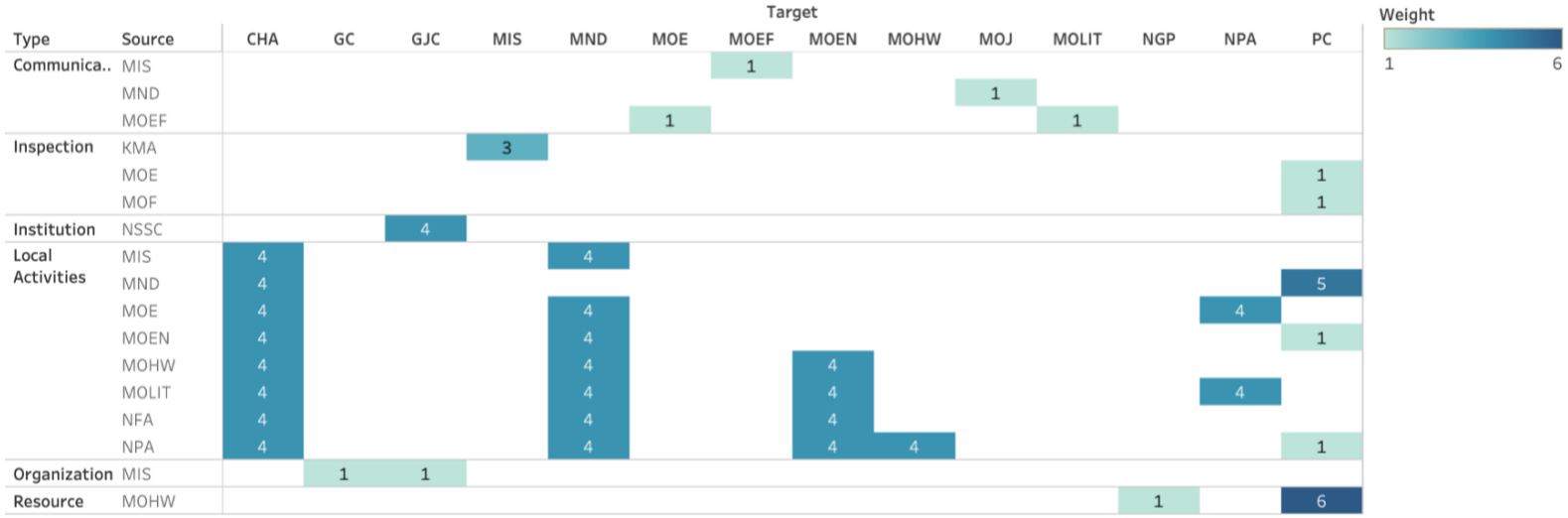
< Week 4 >



Acronyms	
• BC: Busan City • CHA: Cultural Heritage Administration • CWC: Changwon City • DC: Daegu City • GJC: Gyeongju City • HG: Haeundae Gu • KCC: Korea Communications Commission • KMA: Korea Meteorological Administration • MAFRA: Ministry of Agriculture, Food and Rural Affairs • MCST: Ministry of Culture, Sports and Tourism • MND: Ministry of National Defense • MOE : Ministry of Education	• MOEF: Ministry of Economy and Finance • MOHW: Ministry of Health and Welfare • MOI: Ministry of Interior • MOLIT: Ministry of Land, Infrastructure, and Transport • MOTIE: Ministry of Trade, Industry and Energy • MPSS: Ministry of Public Safety and Security • MSIF: Ministry of Science, ICT, and Future Planning • NGP: North Gyeongsang Province • NPA: National Policy Agency • NSSC: Nuclear Safety and Security Commission • PC: Pohang City • SGP: South Gyeongsang Province • UC: Ulsan City

Table 35. Types of Interaction and Frequency among Organizations - Pohang Earthquake

< Week 1 >



< Week 2 >

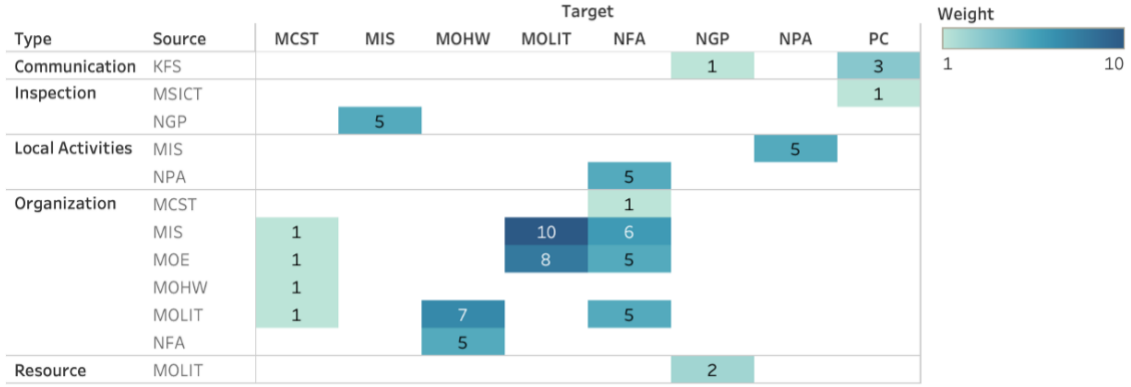
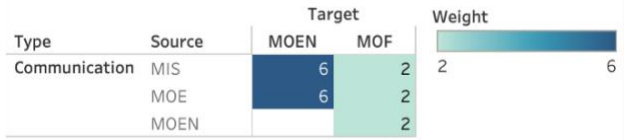


Table 35. Types of Interaction and Frequency among Organizations - Pohang Earthquake (continued)

< Week 3 >



Type	Source	Target: MOEN	Target: MOF
Communication	MIS	6	2
	MOE	6	2
	MOEN		2

Weight: 2 – 6

< Week 4 >

Type	Source	Target: MGEF	Target: MOE	Target: MOHW	Target: PC
Resource	MIS	18	32	30	34
	MOE	18		25	
	MOEL				2
	MOHW	18			
	MOLIT				10
	NFA				6

Weight: 2 – 34

Acronyms	
• CHA: Cultural Heritage Administration • CWC: Changwon City • DC: Daegu City • GC: Gumi City • GJC: Gyeongju City • KFS: Korea Forest Service • KMA: Korea Meteorological Administration • MAFRA: Ministry of Agriculture, Food and Rural Affairs • MCST: Ministry of Culture, Sports and Tourism • MIS: Ministry of the Interior and Safety • MND: Ministry of National Defense • MOE : Ministry of Education • MOEF: Ministry of Economy and Finance • MOEN: Ministry of Environment • MOF: Ministry of Oceans and Fisheries	• MOHW: Ministry of Health and Welfare • MOJ: Ministry of Justice • MOLIT: Ministry of Land, Infrastructure, and Transport • MOTIE: Ministry of Trade, Industry and Energy • MSICT: Ministry of Science and ICT • NFA: National Fire Agency • NGP: North Gyeongsang Province • NPA: National Policy Agency • NSSC: Nuclear Safety and Security Commission • PC: Pohang City • SGP: South Gyeongsang Province • UC: Ulsan City

7.2 Evolving Networks and Dynamics of Fields

As discussed earlier in Chapter 2, the dynamics of fields are identified when an *exogenous shock* destabilizes the network. One source of such an exogenous shock is change(s) in the field(s) on which an actor is dependent. Such a concept is applicable not only to a single crisis but across multiple crises that occurred in dynamic environments. This chapter analyzed how the network of each earthquake had evolved over four weeks following the disasters and compared the respective changes of the networks. The results from the network analysis considering the time factor illustrates how the boundaries of fields had shifted over time. Particularly, the reorganization of the leading disaster management agency, which occurred in between the two earthquakes - from MPSS to MIS - was assumed to have influenced the fields.

At the network level, the change in the number of participating organizations and isolates indicated that while the organizations in the Gyeongju network were gradually disconnected from the network, those of the Pohang network engaged most actively in the first week and then showed a sharp decrease in the second week. Likewise, the density also revealed that the Pohang network had intense participation in the earlier stages followed by a sudden decline in the number of ties. In contrast, the Gyeongju network demonstrated a rather steady decrease in density. The centralization towards a major node presented a diminishing trend for both cases. However, the point at which the centralization values fell was distinctive. Analogous to the progression of the density, the Pohang network had a concentrated network towards the MIS in the first week which dropped substantially the week after. This was comparable to the centralization of the Gyeongju network towards the MPSS, which was relatively higher until the second week. In all, the size, density, and centralization that demonstrated the dynamics of fields at the network level consistently indicated that the difference between the two cases was the point in time at which

these properties registered the biggest rate of change. Seemingly, the Pohang network revealed the transition earlier than the Gyeongju network implying its focus on the early period of response.

The change in subnetwork level communities observed through formation of clusters in each time period provided the dynamic profile of the changing fields. In analyzing the subnetwork level communities, it is important to indicate the nodes that are not involved in the same cluster as well as the nodes that are within the same cluster. By looking at the interplay between nodes across clusters, it is possible to identify that the interdependencies between communities that are likely to have subsequent effects on other communities. The key central and local organizations in the Gyeongju earthquake - the MPSS and GJC - were within the same cluster from week 1 to week 3. In addition, more of the interactions were observed within a cluster than across clusters during the same time period. In contrast, the leading central and local organizations in the Pohang earthquake - the MIS and PC - were separated in different clusters for most of the time range. But the frequency of interaction demonstrated their close relationship across clusters.

Another aspect of the evolving network was to explore how the links across communities have changed. In the Gyeongju earthquake, the first half of the observed period had numerous redundant ties across clusters. That is, rather than a few major organizations interacting with organizations in other clusters, various organizations established relationships with various other organizations creating a complex web between clusters. On the contrary, in the Pohang earthquake, more frequent interactions were observed across clusters even in the earlier period. Furthermore, since the second week, the number of ties crossing the boundaries of clusters diminished meaning less redundancy at the subnetwork level interactions.

The change of networks identified through degree and betweenness centrality revealed some similarities and some differences at the node level. The Pohang network had local

governments with many connections in the early phases while the Gyeongju network had local governments with a lot of connections emerge in the last week. Moreover, the MOHW (Ministry of Health and Welfare) and MGEF (Ministry of Gender Equality and Family) appeared as key actors with respect to connectedness and had quite a consistent influence in the Pohang earthquake but not in the Gyeongju earthquake. On the other hand, the NSSC (Nuclear Safety and Security Commission) was the influential node with many ties in the Gyeongju earthquake though not in the Pohang earthquake. The organizations that served as bridges to link other organizations over time showed similar trends across the two cases. For instance, the leading central agencies and the local government affected by the earthquakes served as bridges throughout the entire period. Furthermore, the number of organizations that bridged others in the earlier phases fell dramatically reflecting the networks that had been loosened towards the later period.

Another node level property, structural holes, provided understanding about which organizations contributed to enhance the efficiency of the network. Analogous to the organizations with high betweenness centrality, the core central agencies and local governments in which the earthquake occurred, had high efficiency values almost the entire period. In addition, the organizations such as MND (Ministry of National Defense) and NPA (National Police Agency) were highly efficient early in the response period for both earthquakes. One of the distinguishable differences was the point at which some of the critical organizations with high efficiency emerged. The MOLIT (Ministry of Land Infrastructure and Transport) served as an important structural hole over the whole period in the Gyeongju network while contributing to the efficiency during the first two weeks of the Pohang earthquake. The MOHW (Ministry of Health and Welfare) and MGEF (Ministry of Gender Equality and Family) were quite dominant structural holes in most of the

period in the Pohang earthquake, while the MOHW became apparent in the third and fourth week of the Gyeongju earthquake.

The types of interactions and the organizations employing those types of interactions were also observed to have evolved over time but in different aspects across the cases. In the Gyeongju earthquake communication was the most prevalent type of interaction in the first three weeks after the earthquake. This is comparable to the Pohang earthquake where the communications were mostly concentrated in week 3. Another distinction was that whereas local activities emerged as the dominant type of interaction in the earlier periods in the Pohang earthquake, it appeared as late as week 3 in the Gyeongju earthquake. One noticeable result common to both networks was observed in week 4, when resource was the major type of interaction. These results illustrate that the types of interaction on which the respective networks relied had not only evolved within the disaster but across the disasters implying likely impacts that reorganization of the core central agency might have engendered.

Then, organizations employing different types of interactions were analyzed. In the first week, the major channel in the Gyeongju earthquake was communication whereas it was local activities in the Pohang earthquake. The frequency of using those types of interaction indicated that the Gyeongju network had relatively loose ties among various actors while the Pohang network showed intense relationships among a few organizations. Later in week 4, both networks had resource as the dominant type of interaction but while the Gyeongju network had closer relationships with the local governments, the Pohang network was not active in exchanging resources with the local governments other than the PC. Instead, in the Pohang earthquake the interaction with the local governments other than the PC, were identified in the first week.

In sum, disparities were identified in the time period at which the networks most actively engaged organizations. Generally, seen through network and node level measurements, the Pohang network tended to focus on the early period of the response. Especially in relations to the local governments, the Pohang network developed ties to the local governments mostly in the early phases while the Gyeongju earthquake maintained the connections till later periods. The subnetwork level clusters revealed that while the major central organization and the local government of the Gyeongju earthquake were within the same cluster in the first two weeks, those of the Pohang earthquake were separated into different clusters. Such a result suggests that subnetwork level interaction across clusters might have been affected by the structural differences of the major central organization. That is, while the MPSS sustained close ties to GJC enhancing cohesion within the cluster, the MIS managed to build relationships across the clusters. The types of interactions and the organizations employing those ties also varied. Whereas communication was the dominant type of interaction in the Gyeongju earthquake, local activity was the major type of interaction in the Pohang earthquake especially in the first week. Later in week 4, both networks evolved to have the resources as the prevalent type of interaction.

In addition to evolution of networks at different levels in respective cases the dynamics of fields were identified across the two cases. Reorganization of the core disaster management agency, seen as the exogenous shock, was thought to contribute to such dynamics of fields at least seen through the measurements employed in this chapter. The most distinguishable difference was that the MIS concentrated its response effort in a comparably earlier phase. Referring to the discussion on "starting conditions" (Ansell and Gash, 2008) versus "authorizing environment" (Rethemeyer and Hatmaker, 2008), it was quite evident that the starting conditions did not remain the same. For instance, after experiencing the Gyeongju earthquake, new organizations and institutions were

created and this became an “authorizing environment”, subsequently affecting the “starting conditions” of future disasters. Thus, there is no conflict between the two concepts when networks are thought to evolve, as evidence has shown in this chapter.

8.0 Conclusion

Government organizations are characterized by hierarchy and control, which gives the impression that they are rigid and unable to perform flexibly when challenged by unexpected disasters. However, government agencies and various local governments do put a lot of effort into achieving success amid abnormal situations. In fact, various collaborative attempts were observed among government organizations in response to disasters as seen from the recent earthquake cases in Korea. This research explored interorganizational networks among government organizations including government agencies and local governments faced by unprecedented disasters. Rather than analyzing the network of a single case, the networks of two different earthquake cases were selected and compared. This analysis sought to identify the relationships between government organizations' structural changes and interorganizational networks, since there was a reorganization of the key disaster management agency between the two earthquake cases. The goal of this study was to derive implications on how to enhance network effectiveness during dynamic conditions highlighting its relation to functional arrangements implied in the boundary of fields.

To achieve the goal, this research was designed as a comparative case study disclosing interorganizational networks of the two earthquake cases in Korea that had occurred in 2016 Gyeongju and in 2017 Pohang. A pattern matching technique was employed to make judgments about causal status of relationships by matching theoretical patterns with empirical patterns. This analysis assumed that there would be distinguishable differences in network properties between the two cases due to the reorganization of the control center in disaster management. Although the unit of collecting data and observation for collecting data was the individual organizations, the unit of analysis throughout the research was the network. The focus was on how the networks develop

and change in dynamic environments. However, different levels of the networks were explored to support the focus of study which is the network. For instance, the groups of organizations at the subnetwork level were analyzed to demonstrate the strategic action fields which operate within the whole network. The method of social network analysis was applied to identify the structural aspects of the network, stressing linkages, coordination, and collaborations among actors (Hawe et al., 20014; Tichy et al. 1979). In addition, semi-structured interviews were conducted to complement the network analysis by carefully structured questions designed to derive answers based on actors' perception and judgment.

There is a tension between scholars on whether the environments in which networks develop are "starting conditions" (Ansell and Gash, 2008) or "authorizing environments" (Rethmeyer and Hatmaker, 2008). These concepts, which are drawn from the collaborative governance model, were applicable to the network settings. Many of the starting conditions were recognized to affect both earthquakes equally: the disaster management system, institutions and policies, and experience of disasters. Yet, there was also a condition that differentiated the initial conditions of the two earthquakes: the experience of a relatively recent disaster, the Gyeongju earthquake itself, which enabled learning before the Pohang earthquake. Thus, the fact that starting conditions were not identical with respect to experiencing a recent disaster was considered in interpreting the results.

Various aspects linking the reorganization and its impact on interorganizational networks were pursued. The descriptive analyses on how the networks developed in each case yielded some interesting findings. First, at the network level, the analysis showed that whereas the number of existing links out of possible links was higher in the Pohang earthquake, the extent to which nodes were centralized under the key node was higher in the Gyeongju earthquake. This demonstrates

the possible gap between overall speed of information flow and dependency on a certain node for information.

Second, different measurements employed at the node level revealed distinguishable results between the two cases. When the influence of an organization was measured by connectedness, local governments played an important role in the Pohang earthquake. However, when the extent of influence was measured by how much it was connected to other influential nodes, local governments turned out to be more critical in the Gyeongju earthquake. This result was reversed when the extent of bridging other two nodes was measured. That is, local governments in the Pohang earthquake were able to interact with other organizations without going through the MIS whereas local governments in the Gyeongju earthquake relied much on the MPSS when interacting with other organizations. Efficient organizations, or structural holes, across the two cases were assessed to have contributed to stability of the network.

Third, the subnetwork level was examined through both clusters of communities and cliques. Based on the combined results, organizations that were involved within the same subnetwork level clusters and communities across the cases were the Cultural Heritage Administration (CHA) and Ministry of Education (MOE) implying their constant intimacy within the network. In contrast, organizations with close relationships in one case but not in the other were: the Ministry of Science ICT and Future Planning (MSIF), Ministry of Trade, Industry and Energy (MOTIE), and Ministry of Agriculture, Food and Rural Affairs (MAFRA) in the Gyeongju earthquake; and the National Fire Agency (NFA) and Ministry of Environment (MOEN) in the Pohang earthquake. Such results indicate the shift in boundaries of fields from a broader array of science, trade, industry, agriculture, and food etc. to more focused fields of fire and environment.

Fourth, semi-structured interviews were analyzed to look at the dynamic environments and adaptation to them. One noticeable discrepancy between the MPSS and MIS was that the MIS was better in drawing on local support. This was assessed to be due to their power over resources, personnel, and financial aids. Adaptation of networks observed through network analysis was also supported by the interview accounts. That is, high centralization towards the major organization, the MPSS, in the Gyeongju network came to be relatively more dispersed in the Pohang earthquake engendering cooperative patterns. Yet, there were seemingly inconsistent results between network analysis and the interview results on the relationship between the MPSS and local governments. Many of the interviewees contended that the MPSS did not have the power to induce support from the local governments contrary to the results from network analysis that indicated local actors were largely dependent on the MPSS. Apart from their actual willingness to cooperate with the MPSS at implementation, the network demonstrated the involvement of the local actors bound by law. In addition, the more disseminated communicative power in the Pohang earthquake could be explained as adaptation after experiencing the Gyeongju earthquake, which created institutions and brought about systematic investment related to earthquakes risk.

Another major question was the relationship between reorganization and network effectiveness. While the common definition of effectiveness involves achievement of desired or expected outcomes, the operational definition of network effectiveness in this research suggested a more comprehensive approach. In disaster settings, it is difficult to expect outcomes since the environments change constantly. Furthermore, various actors within the network make it challenging to determine what the desired outcomes or results are. Thus, based on structural and procedural aspects of network effectiveness, extensive measurements are employed at different levels of networks along with shared understanding of the disaster response network.

The propositions were derived based on theories and were subsequently matched with empirical patterns. Then, results of the pattern matching confirmed, disapproved, or refined the propositions. It was proposed that consolidating similar functions within one organization, like the MPSS, had positive impacts to network effectiveness. Inversely, consolidating dissimilar functions within one organization, like the MIS, was proposed to have negative impacts to network effectiveness. Finally, incorporating similar functions within an organization enhanced mechanisms of network integration, leading to network effectiveness.

Empirical patterns based on government reports and interview data were observed employing various measurements of network effectiveness. To reiterate briefly, network effectiveness was measured by degree and betweenness centralization (network level), clique cohesion and clique overlap (sub-network level), and degree and betweenness centrality (node level) each based on the literature. As noticed from their terms, centralization and centrality measures are closely related by definition. Therefore, the network level and node level were analyzed in relation to each other. In terms of both degree and betweenness, the MPSS was found to be better in achieving network effectiveness. By incorporating similar functions, the safety and disaster functions within the MPSS, clear recognition regarding the points of control and coordination were elicited.

Clique cohesion and clique overlap indicated that overall clique cohesion was higher in the Pohang network, but the Gyeongju network revealed greater clique cohesion when the top three most cohesive cliques were compared. The number of overlapping members of the major cliques was the same across the earthquake cases. But, looking closer at the overlapping members of the key cliques, the Ministry of Science, ICT and Future Planning (MSIF) in the Gyeongju earthquake;

and the Ministry of Education (MOE) and Ministry of Health and Welfare (MOHW) in the Pohang earthquake were distinctive organizations through which learning could be disseminated.

Interview data were used to explore how the consolidation of functions was linked to the mechanisms of network integration that led to network effectiveness. Among the mechanisms of network integration drawn from the literature, communication system and joint activities partially supported the theory on which the proposition was based. However, there was also evidence supporting the counter theory that conflicted with the proposition. For example, interview results confirmed the theory by stating that the MPSS, which consolidated similar functions, established organizations to enhance joint activities. In addition, in making decisions, the MPSS prioritized safety and disaster functions which enhanced its capacity in joint activities. Yet, there were also statements that supported the counter theory saying that some of the institutions, although they had existed before, were implemented in the Pohang earthquake by the MIS, which consolidated dissimilar functions. Moreover, the MIS was evaluated to be better at coordinating other organizations to have better relationships with the local governments where implementation takes place.

In addition to the elements derived from literature, additional themes observed from the interview data were incorporated into the match of patterns between theory and empirical data. With respect to power and resources, the MPSS did have the legal authority to control other disaster management agencies but lacked power and resources to draw on local support. In contrast, the MIS was able to stimulate the local actors with their resources indirectly associated with response activities.

The results of comprehensive pattern matching helped to refine the propositions. First, at the network and node level, the proposition suggesting a positive relationship between

consolidation of similar functions and network effectiveness was confirmed. However, the sub-network level needs further information to determine whether the focus of the network is on the overall dissemination of information or on concentrated effort by the major organizations forming cliques. That is, if all the cliques are considered, consolidating dissimilar functions showed higher cohesion. If only major cliques are considered, consolidating similar functions showed higher cohesion. Second, the proposition that sought a negative relationship existed between consolidation of dissimilar functions and network effectiveness was largely contradicted. Third, the relationship between consolidation of similar functions and mechanisms of network integration was only partially supported with mixed results. While the MPSS was considered to enhance communication system and joint activities, the MIS was judged to be better in terms of assigning roles to other organizations and its relationship with the local actors. It was unclear whether the reorganization expedited learning. Instead, learning through experience of disasters accumulated with time and enhanced network effectiveness.

The evolution of networks in dynamic environments was analyzed with respect to changes observed in network structures and the types of interactions. The network properties of respective earthquakes were broken down into four weeks and then compared. By doing so, not only evolution of networks within each earthquake but also the dynamics of fields across the cases were noted. Noticeably, the time points at which the two earthquake networks showed the biggest rate of change were different. That is, the MIS in the Pohang network tended to focus on the earlier response phase followed by a sharp fall. This contrasted with the MPSS, which maintained a rather steady rate of change until the later periods. Another difference was observed at the sub-network level where the Gyeongju earthquake had redundant ties across clusters among numerous organizations in the first two weeks while the Pohang earthquake revealed less redundant ties

across clusters since the second week. Such a contrast illustrates that the Pohang network was able to manage a relatively more efficient network with less redundant ties crossing boundaries of clusters.

With respect to types of interactions, the Gyeongju network had communication as the dominant type of interaction for the first three weeks whereas the communication in the Pohang network was mostly observed in week 3. However, local activities were the prevalent type of interaction in the early response period of the Pohang network, while this type emerged later in week 3 of the Gyeongju network. The frequencies of interaction through the major types of interactions in the first week of the two earthquakes - communication in Gyeongju and local activities in Pohang - revealed that the Gyeongju network had comparably loose ties among various organizations while the Pohang network had intense ties among a few organizations. Regardless of the types, the relationship with the local actors also corroborated the tendency of the Pohang network to develop ties in the earlier phases whereas the Gyeongju network maintained the connections until the later periods.

The theoretical contribution of this research is that government organizations, often considered as boxes and lines of hierarchical structures, are not only viewed as mere components of networks, but also are important factors that affect other proximate and distant fields. Such an approach, combined with the complex adaptive system framework, facilitated this research to incorporate dynamic environments into the scope of research rather than controlling them. Moreover, the results and findings from this analysis rightly demonstrated how the fields have shifted as a result of exogenous shock, the reorganization. Thus, this research also contributed to supporting the grounds for theory of fields by utilizing the empirical data and drawing on actual practice. Another contribution is linking government reorganization to network effectiveness.

Instead of merely focusing on the structural consequences of reorganization, this research highlighted the procedural aspects as well. As a result, the impacts of reorganization of government agencies were explored in terms of functions as reflected in their change of fields.

The methodological contribution of this research is employing the pattern matching technique to make judgments about causal status of relationships along with cross-case analysis and network analysis. This is constructive since cross-case analysis and network analysis are inadequate methods to identify causal relationships. Therefore, using pattern matching to assess relationships between factors stated in the propositions clarifies the propositions. This analysis serves as a good example of how diverse methodologies can be interconnected to complement one another's weaknesses. Furthermore, this research used the strengths of semi-structured interviews which allows flexibility driven by the informant and elicited additional themes from the interviews. This method was applied in chapter 6, in which primary themes based on theories were determined before conducting the interviews. Additional themes such as power and resource, experience of disaster, and balance between coordination and expertise were later incorporated, elaborating the analysis.

Several practical implications were attained, providing a basis on which public officials and managers could devise plans for more effective networks in disasters. First, some functions maintain their importance despite changing environments. Referring to the concepts of fields, fields that are likely to be constant despite exogenous shocks enhance the stability of the network. Thus, the organizations that kept high influence across different measurements and cases should serve as the focal point in the disaster management system - e.g. Ministry of Land, Infrastructure and Transport (MOLIT), Ministry of Health and Welfare (MOHW), Ministry of National Defense (MND), and National Police Agency (NPA). On the contrary, organizations constituting fields that

revealed greater influence in one case but not in the other should commit to reinforcing flexibility amid dynamics - e.g. Ministry of Science, ICT and Future Planning (MSIF), Ministry of Trade, Industry and Energy (MOTIE), and Ministry of Agriculture, Food and Rural Affairs (MAFRA); National Fire Agency (NFA) and Ministry of Environment (MOEN).

Second, having actual resources and power is critical to induce support from other actors within the network rather than merely being prescribed by the law. The MIS, with their power over resources, was able to gain local support in response to the earthquake. In contrast, the MPSS had the legal basis for their authority, but lacked the actual influence of the MIS.

Third, while consolidating the safety and disaster functions within a single organization could be better in terms of rapid decision making, having different functions within one organization facilitated coordination among various actors. The types of interactions that respective earthquakes involved in the early phases, communication in Gyeongju and local activities in Pohang, corroborated such a result. Moreover, the points at which each core agency showed the most intensive effort in response, were distinguishable. The MIS concentrated its energy in relatively earlier phases whereas the MPSS sustained the network until later points in time. It would be difficult to assert that this is directly attributable to their functional arrangements, but it is consistent with the interview statements that informed the MIS was able to gain cooperation quickly from other organizations with its power over them.

Several limitations in this research led to future research agenda. First, the data employed for the network analysis was based on the government report published by the government agency, which was also the subject of this research. Although the report is considered objective and unbiased, the data are not exhaustive and so could have omitted some critical information. Second, the interviewees were selected purposely to include those who had sufficient experience and

relevant knowledge to provide valid information regarding organizational performance in reference to the two earthquake events. However, this process could have precluded other perspectives, for instance, the local aspect towards the network. Third, the evolution of networks was observed within a limited time range. This was partly due to the data available and partly due to the focus of the research investigating the early response phase of disaster management. Yet, different results and implications could be drawn once the time range is extended to a longer period. Finally, the context of government reorganization may not be applicable to all the countries. This was indicated in the context of Korea where the president holds substantial power over reorganization which elicited frequent government reorganizations. Thus, to employ implications drawn from this research, specific contexts first need to be considered.

Based on these limitations, I suggest future research agenda that could advance the field of research. First, future research might consider expanding the source of data to encompass broader perspectives. For example, the data for network analysis may be collected from the local governments which could represent more of the local perspective. If the results of such analysis differ from the results of this research, it would be interesting to seek why. Moreover, this approach could also be applied in selecting the interviewees to cover a wider variety of aspects in different organizations and sectors. Second, it would be meaningful to extend the time range of analysis to a longer period. Although this research highlighted the response phase, the recovery phase might provide compelling implications about ways to reinforce disaster management system.

In all, consistent study is required to enhance the field of disaster management, especially with respect to interorganizational networks. Although a myriad of inquiries on networks have accumulated for decades, elaboration is needed to link the measurement of networks to specific

concepts applicable in practice. This research was conducted as one of such an attempt and provided some constructive findings that could be strengthened by further studies.

Appendix A

Appendix Table 1. Structural Hole - Efficiency Values by Week (Gyeongju)

	Week 1		Week 2		Week 3		Week 4	
	Organiz-ation	Efficiency	Organiz-ation	Efficiency	Organiz-ation	Efficiency	Organiz-ation	Efficiency
1	PC	1.000	NPA	1.000	MND	1.000	UJC	1.000
2	HG	1.000	UJC	1.000	UJC	1.000	MSIF	1.000
3	GC	1.000	UC	1.000	GJC	0.744	PC	1.000
4	CWC	1.000	BC	1.000	MPSS	0.679	UC	1.000
5	UJC	1.000	NGP	1.000	MOHW	0.587	MPSS	0.863
6	DC	1.000	SGP	1.000	MCST	0.500	GJC	0.839
7	SGP	1.000	MPSS	0.843	MOLIT	0.494	MOI	0.714
8	MPSS	0.827	GJC	0.686	MSIF	0.468	NSSC	0.714
9	MOLIT	0.610	MSIF	0.590	MOI	0.442	MOHW	0.500
10	MOI	0.540	MOI	0.572	MOEF	0.381	MCST	0.495
11	GJC	0.522	KCC	0.562	CHA	0.381	MOLIT	0.432
12	MND	0.500	MOEF	0.550	MOE	0.371	-	-
13	NPA	0.500	KMA	0.538	MOTIE	0.371	-	-
14	UC	0.481	MOLIT	0.520	KMA	0.371	-	-
15	BC	0.481	MND	0.500	NSSC	0.349	-	-
16	NGP	0.444	MOHW	0.500	-	-	-	-
17	KMA	0.334	MOTIE	0.482	-	-	-	-
18	MSIF	0.334	NSSC	0.482	-	-	-	-
19	MOE	0.323	CHA	0.482	-	-	-	-
20	MOTIE	0.323	MOE	0.456	-	-	-	-

21	NSSC	0.323	-	-	-	-	-	-
22	MAFRA	0.267	-	-	-	-	-	-
23	CHA	0.267	-	-	-	-	-	-

Appendix Table 2. Structural Hole - Efficiency Values by Week (Pohang)

	Week 1		Week 2		Week 3		Week 4	
	Organiz-ation	Efficiency	Organiz-ation	Efficiency	Organiz-ation	Efficiency	Organiz-ation	Efficiency
1	GJC	1.000	KFS	1.000	PC	1.000	PC	1.000
2	KMA	1.000	MSICT	1.000	MIS	0.635	MOEL	1.000
3	GC	1.000	PC	0.822	MOE	0.513	MOLIT	1.000
4	MOEL	1.000	NGP	0.793	MOEN	0.506	NFA	1.000
5	MOF	1.000	NPA	0.694	MOF	0.506	MIS	0.625
6	KFS	1.000	MIS	0.692	MOHW	0.383	MOHW	0.333
7	NSSC	1.000	MOLIT	0.670	MGEF	0.383	MOE	0.333
8	MOJ	1.000	NFA	0.510	-	-	MGEF	0.333
9	MIS	0.649	MCST	0.477	-	-	-	-
10	PC	0.532	MOHW	0.406	-	-	-	-
11	MGEF	0.521	MOE	0.398	-	-	-	-
12	MOEF	0.515	MGEF	0.358	-	-	-	-
13	MND	0.502	-	-	-	-	-	-
14	NGP	0.486	-	-	-	-	-	-
15	MOLIT	0.476	-	-	-	-	-	-
16	MOHW	0.440	-	-	-	-	-	-
17	NFA	0.432	-	-	-	-	-	-
18	NPA	0.431	-	-	-	-	-	-
19	MOEN	0.431	-	-	-	-	-	-

20	MOE	0.424	-	-	-	-	-	-
21	CHA	0.393	-	-	-	-	-	-

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