Constructing social resilience : a perspective of organisational structure and informational relation

Tasic, Justyna Katarzyna

2019

Tasic, J. K. (2019). Constructing social resilience : a perspective of organisational structure and informational relation. Doctoral thesis, Nanyang Technological University, Singapore.

<https://hdl.handle.net/10356/88679>

<https://doi.org/10.32657/10220/48033>

**NANYANG
TECHNOLOGICAL
UNIVERSITY**

SINGAPORE

**CONSTRUCTING SOCIAL RESILIENCE:
A PERSPECTIVE OF ORGANISATIONAL
STRUCTURE AND INFORMATIONAL RELATION**

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Interdisciplinary Graduate School

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2019

Statement of Originality

I hereby certify that the work embodied in this thesis is the result of original research, is free of plagiarised materials, and has not been submitted for a higher degree to any other University or Institution.

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Justyna Katarzyna Tasic

Supervisor Declaration Statement

I have reviewed the content and presentation style of this thesis and declare it is free of plagiarism and of sufficient grammatical clarity to be examined. To the best of my knowledge, the research and writing are those of the candidate except as acknowledged in the Author Attribution Statement. I confirm that the investigations were conducted in accord with the ethics policies and integrity standards of Nanyang Technological University and that the research data are presented honestly and without prejudice.

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Assoc. Prof. Sulfikar Amir

Authorship Attribution Statement

This thesis contains material from three papers published or accepted for publishing in the following peer-reviewed journals where I was the first author.

Chapter 2 is published as Tasic J., Tantri F. & Amir S. (2019). Modelling Multilevel Interdependencies for Resilience in Complex Organisation. *Complexity* 2019. DOI: 10.1155/2019/3946356.

The contributions of the co-authors are as follows:

- Fredy Tantri advised on the multilevel interdependence degrees measures, which I designed and calculated.
- I collected the sociometric data and constructed organizational structure layers.
- I prepared the settings of agent-based model and simulations, which were programmed by Fredy Tantri. I analysed and interpreted the simulation results.
- I prepared the manuscript, which was revised by Assoc. Prof. Sulfikar Amir.

Chapter 3 is published as Tasic, J. & Amir, S. (2016). Informational Capital and Disaster Resilience: The Case of Jalin Merapi. *Journal of Disaster Prevention and Management*, 25(3), pp. 395-411. DOI: 10.1108/DPM-07-2015-0163.

The contributions of the co-authors are as follows:

- Assoc. Prof. Sulfikar Amir suggested the case study area, advised on conceptualisation part, and contributed to the revisions of manuscript.
- I prepared the manuscript, collected the empirical data and analysed them.

Chapter 4 is accepted for publishing as Tasic J., Amir S., Tan J. & Khader M. (in press).
Multilevel Framework to Enhance Organisational Resilience. *Journal of Risk Research*.

The contributions of the co-authors are as follows:

- I designed the framework and prepared the manuscript, which was revised by Assoc. Prof. Sulfikar Amir.
- I consulted the measured metrics with Jethro Tan who also supported collection of the empirical data for the framework validation.
- Asst Prof. Majeed Khader contributed to the questionnaires design and manuscript review.

12.04.2019

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Date

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Justyna Katarzyna Tasic

Acknowledgements

I am grateful for the opportunity to join the vibrant environment of Nanyang Technological University and the Institute of Catastrophe and Risk Management. This thesis would not have been possible without the support of many individuals whom I met during the course of my PhD. First and foremost, I would like to express my sincere gratitude and appreciation to my supervisor, Associate Professor Sulfikar Amir, who has always been an inspiring motivator and shared his passion to trying new creative approaches in formulating and solving important research problems. I am thankful for his continuous professional and personal support. My gratitude extends to my co-supervisor Assistant Professor Georgios Christopoulos and mentor Professor Quah Teong Ewe, Euston, for their continuous support throughout my PhD candidature. I deeply appreciate Prof. Hans Rudolf Heinemann for the advices, which supported conceptualisation of organisational interdependencies.

I am grateful for the opportunity to visit Home Team Behavioural Sciences Centre, Ministry of Home Affairs, Singapore. It was a very valuable experience to work with and learn from their experts in resilience and crisis management.

My heartfelt appreciation goes to my co-workers and friends from Future Resilient Systems, Fredy Tantri, Mateusz Iwo Dubaniowski, Dr. Miltos Kyriakidis, Ylenia Casali, Martina Cecchini, Beatrice Cassottana, Dirk-Jan Van Veen, Dionysios Georgiadis, Swati Sharma, Dr. Aakil Caunhye, Dr. Marco Cinelli and others, for lively discussions on resilience and cheerful support.

I am also thankful to students attending the course on Science, Technology, and Society, which I was supporting as teaching assistant. Thank you for your curiosity, creativity and fostering my teaching skills.

Special words of appreciation are dedicated to all administrative staff at the Institute of Catastrophe and Risk Management (ICRM), Interdisciplinary Graduate School, and Future Resilient Systems, Singapore-ETH Centre, who have always been welcoming and assisted in arranging needed resources and ensuring proper flow of administration processes.

I would like to acknowledge the financial support from Institute of Catastrophe and Risk Management (ICRM) and Interdisciplinary Graduate School, Nanyang Technological University, and Future Resilient Systems, Singapore-ETH Centre, which is a collaboration between ETH Zurich and National Research Foundation (NRF) Singapore (FI 370074011) under the auspices of the National Research Fund's Campus for Research Excellence and Technological Enterprise (CREATE) programme.

I wish to also express gratitude to the Resilience Engineering Association for the Young Talent Award and inviting me to the 7th Symposium of Resilience Engineering Association (Liege, Belgium, 2017).

Lastly, I would like to take this opportunity to thank my family and friends, who have always believed in me and gave me the courage to complete this long journey.

Singapore, November 2018

Justyna Tasic

*To my parents, Ewa and Adam, and my husband, Velimir,
who always have encouraged and supported me on this endeavour.*

Abstract

Recently, the notion resilience has received a lot of attention from scholars, organisations, communities, and governments to enhance capacity in dealing with growing risks and uncertainties. This research addresses the major challenge of apprehending resilience from a social science perspective. More specifically, through the compilation of three papers, this thesis seeks to better understand key factors of social resilience and propose new ways to enhance it. The dissertation highlights that social resilience is strongly related to social interactions, flow of information, and organisational structures and their context. To accomplish its research objective, this thesis explores 1) how organisational interdependencies affect emergency response at multiple levels; 2) how organised trust-based interactions and information dissemination can enhance disaster resilience; and 3) how an organisation can enhance its resilience capacity through multilevel management efforts. The dissertation employs a case study approach to explore how social resilience is shaped in different contexts. The case study analyses combine both qualitative (observation, interviews, document studies, open-ended questionnaire) and quantitative methods (social network analysis, agent-based modelling, closed-ended questionnaire). This thesis advances resilience and crisis management studies with the concepts of 1) multilevel interdependencies in complex organisational systems and 2) informational capital in crisis management settings, as well as proposes 3) the multilevel framework to enhance organisational resilience. The dissertation makes a significant contribution to improving resilience practices through a framework that captures how organisations can self-assess crisis preparedness and response capacity, and learn to enhance resilience. The thesis highlights workable solutions and policy recommendations, which are expected to inform practitioners in applying more comprehensive strategies for resilience and crisis management.

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Glossary of Key Terms

Community disaster resilience is a critical feature of community that allows effective mobilisation of its resources and capabilities to overcome negative consequences of disaster and recover from it.

Crisis management is the process by which an organization deals with disruptions that can threaten the organization or its stakeholders. It includes mitigation, preparedness, response and recovery activities.

Disaster management is managing risks to communities through policies, plans, procedures and practices that are in place before a disaster occurs, as well as all actions undertaken when and after disaster occurs. It includes mitigation, preparedness, response and recovery activities.

Informational capital refers to the mutual trust and genuine participation in production and dissemination of information facilitated by the use of information technology by a community in disaster management processes.

Jalin Merapi Network (*Jaringan Informasi Lingkar Merapi*—Information Network Around Volcano Merapi, JMN) was founded in 2006, following the Bantul earthquake, a tragic disaster that killed almost five thousand people and caused a mid-eruption of Merapi. The network emerged as a bottom-up initiative of three community-based radio stations located around the volcano, two community radio networks, and four local NGOs. Using the advantages of information technology, JMN supported disaster response and recovery actions in the 2010 eruption.

Multilevel interdependencies in organisational systems are formal and informal social exchange relationships nested at five levels: individual, intraunit, interunit, intraorganisational, and interorganisational. Chapter 2 describes measures to calculate multilevel interdependence degrees and how they can be used for analysis of organisational resilience.

Resilience is a critical feature of an organisation or community that allows effective mobilisation of its accumulated resources and capabilities to overcome the unexpected disruptions.

Resilient organisational system as being proactive in mobilizing its resources and capabilities to effectively perform under a variety of conditions. Organisational resilience can be assessed through analysing of system performance (robustness and recovery) under different conditions that include both normal operations and disruptions.

Social capital refers social relationships (social networks) as well as mutual trust that arises from them. Social capital is considered to have many advantages for building mutual support, cooperation, and organisational effectiveness. There are types of social capital: bonding (horizontal relationships —i.e. between people of the same social status—in homogenous social groups e.g. friends, family, community), bridging (horizontal relationships in heterogenous social groups with open for new resources, e.g. organisations), and linking (vertical relationships with authorities).

1. Research Summary

1.1. Introduction

Living in the times of turbulent changes brings the concept of resilience into the centre of attention of organisations, communities, and governments, which strive to achieve resilience capacity. Resilience is a critical feature that allows effective mobilisation of accumulated resources and capabilities to overcome the unexpected. As a dynamic process that arises at multiple levels, resilience can be built and enhanced over time by adjusting and strengthening capabilities. To address the problem of achieving and maintaining an expected level of resilience, it is important to first better understand what are the factors that shape resilience capacity and how they affect it. This research addresses the major challenge of apprehending resilience from a social science perspective. In this view, resilience is deeply rooted in social interactions, flow of information, and organisational structures. The capability to understand and manage those key factors is essential to build and enhance social resilience. Empirically, the dissertation investigates social resilience in two scopes, namely organisation and community. To explicate how resilience is affected by the key factors, the thesis explores 1) how organisational interdependencies affect emergency response at multiple levels; 2) how organised trust-based interactions and information dissemination can enhance disaster resilience; and 3) how an organisation can enhance its resilience capacity through multilevel management efforts.

Contributing to understanding how social resilience is formed and enhanced, this research is scientifically significant as it offers new theoretical and practical concepts for resilience governance and crisis management studies. Specifically, the thesis proposes the concepts of 1) multilevel interdependencies in complex organisational systems, and 2) informational capital

in crisis management settings, as well as presents 3) the multilevel framework to enhance organisational resilience. The dissertation advances resilience practices with a framework that helps organisations to enhance their resilience capacity. In addition, the thesis highlights workable solutions and policy recommendations to inform practitioners in creating more comprehensive strategies for resilience management.

All thesis sections present social resilience as a critical feature that allows effective mobilisation of accumulated resources and capabilities to overcome the unexpected disruptions. The thesis chapters highlight that social resilience is shaped by social relations, their structures and context as well as the flow of information. The research takes advantages of case study approach, which analyses shaping social resilience in different contexts that are investigated with social network analysis as one of the main research methods.

One important factor of social resilience that binds all thesis parts is social structure, which exists in both communities and organisations. In other words, communities and organisations are described as assemblages of formal and informal structures, which guide their actions in disruptions. In particular, the trust-based interactions, i.e. informal networks, are presented in all chapters as crucial element of social resilience. In addition, the thesis investigates social structures from the perspective of internal and external contexts, for example, 1) in the multilevel interdependencies analysis the internal-external perspective was changing depending on the analysed level, 2) all phases of the multilevel framework focused on internal organisational capabilities and external relations with stakeholders, and 3) the case study on informational capital analysed the internal organisational and community arrangements as well the external institutional landscape.

The flow of information is another component that conditions social resilience that links all parts of the thesis. In this regard, the thesis underlines that well-developed informational

relations at multiple levels are essential for managing the unexpected conditions. This was evident in 1) multilevel disaster management activities led by the three types of social capital (bonding, bridging, and linking), 2) multilevel crisis response to the two tested scenarios (“Secret” data loss and terrorist attack), and 3) simulations of multilevel organisational communications to deal with a major disruption.

In the following lines, the appropriate literature insights are introduced. Up to date, the notion of resilience has been applied in a wide variety of academic fields, including ecology (Carl Folke, 2006; C. Folke et al., 2010; Gallopín, 2006), sociology (Adger, 2000), psychology (Ong, Bergeman, Bisconti & Wallace, 2006), supply chain management (Sheffi & Rice, 2005), strategic management (Hamel & Välikangas, 2003), disaster mitigation (Paton & Johnston, 2017; Tasic & Amir, 2016), sociotechnical systems (Amir & Kant, 2018; Kant & Tasic, 2018), resilience engineering (Hollnagel, Woods & Leveson, 2006; Nancy Leveson, 2004), organisational reliability (La Porte, 1996; Weick & Sutcliffe, 2011; Weick, Sutcliffe & Obstfeld, 1999), and resilience management (Bhamra, Dani & Burnard, 2011; Boin & Van Eeten, 2013; Heinemann & Hatfield, 2017). Next paragraphs describe the concept of resilience with a primary reference to resilience engineering and management studies, which constitute the most relevant ground for this dissertation due to their focus on social facet of resilience.

Scholars believe that resilience offers a potential solution to withstand disruptions and shocks in organisational systems, thus creating the environment for organisational longevity. In 2006, a group of experts in industrial and system safety initiated an organisation-centred paradigm called *resilience engineering* (Hollnagel et al., 2006) in response to what they thought be the incomplete view on safety that was widely evident in the research and practice. Resilience engineering scholars deemed existing methods as inadequate for understanding safety in complex systems (strict focus on error per se and skipping the meaning of the context)

(Hollnagel et al., 2006). Even perfectly functioning systems can fail from the complex interaction between its components (N. Leveson, Dulac, Marais & Carroll, 2009, p. 234). Safety characterizes organisational system performance—it is not something what an organisation possesses, but rather what it does, and it cannot be taken for granted (Hollnagel et al., 2006). Hollnagel et al. (2006) explored different aspects of resilience, which they described as an intrinsic ability of a system to maintain or regain state that allows continuous operations after a major disruption. Recently, these developments continue in the people-oriented definition of resilience seen as “an expression of how people, alone or together, cope with everyday situations – large and small – by adjusting their performance to the conditions” (Hollnagel, 2017, p. 14). Resilience in the field of management is generally regarded as an emergent property that relates to the inherent and adaptive qualities of an organisation to mitigate risk (e.g. Burnard & Bhamra, 2011). Therefore, resilient organisational systems are proactive in mobilizing their resources, use their abilities and adapt to perform under a variety of conditions (both expected and unexpected).

How do social interactions, flow of information, organisational structures and their context affect resilience? As pointed out by many researchers, complex system organisations are composed of multiple levels of operation (Comfort, Sungu, Johnson & Dunn, 2001) in which interconnected agents form a network of nonlinear relationships that give rise to emergent behaviours (Bhamra et al., 2011). The more complex the organisation, the more complex the response process to disruptions will become (Comfort et al., 2001). Similar to safety, resilience is seen as a systemic property where individual, group, and organisational levels have a reciprocal influence on each other (Riolfi & Savicki, 2003; Sutcliffe & Vogus, 2003). From this vantage point, managing resilience is “as a matter of a balancing between individual resilience (individual responses to operational challenges) and system resilience (the large scale autocatalytic combination of individual behaviour)” (Hollnagel et al., 2006, p. 88). In

addition, organisations are embedded in interorganisational relationship, which are crucial for sustaining their operations (Klibi, Martel & Guitouni, 2010; Provan, Fish & Sydow, 2007; Sheffi & Rice, 2005). Organisations are more likely to be resilient if they can effectively mobilise internal and external resources and capabilities (Sutcliffe & Vogus, 2003). Therefore, interorganisational resilience is usually described as adaptability, flexibility and redundancy or diversification (Klibi et al., 2010; Sheffi & Rice, 2005). Applying the systems thinking approach, Nancy Leveson (2004) argued that system's safety is an emergent property, and thus must be controlled at the system level. Consequently, building resilience should be seen as a collaborative process, which requires continuous learning and adaptation from all actors, i.e. across individuals, groups, organisations (Heinimann & Hatfield, 2017; Martina K Linnenluecke, 2017) and interorganisational networks.

Important to highlight in this aspect is the notion of organisational culture as collective mind, an outcome of which Weick and Roberts (1993, p. 23) refer to "a well-developed organization mind, capable of reliable performance" which is "thoroughly social...[and] built of ongoing interrelating and dense interrelations." It is based on the argument that crisis requires collective response, which is the most effective when organised through the collective mindfulness (Weick et al., 1999), i.e. when the shared meanings, respectful interactions, improvisation (Weick, 1993), flexibility (Bigley & Roberts, 2001), and joint responsibility are present (Lengnick-Hall, Beck & Lengnick-Hall, 2011). Well-developed relationships (formal and informal) within and among organisations are fundamental for taking up a joint action during normal and crisis operations (Krackhardt & Hanson, 1993; Krackhardt & Stern, 1988; La Porte, 1996; Weick et al., 1999). Trustful relationships, i.e. social capital, are the fundamental for collective sensemaking, taking up a collaborative action and facilitating organisational resources flow (Gillespie & Dietz, 2009; Krackhardt & Stern, 1988; Weick & Roberts, 1993). In fact, in crisis situations, informal social relations build unconventional bridges cross

organisation to supplement unavailable formal connections. Thus, any resilient organisational system has a strong culture of awareness, and is able to create improvised responsive networks to mitigate a crisis (Boin & Van Eeten, 2013; Krackhardt & Stern, 1988; Tasic & Amir, 2016; Weick et al., 1999). Therefore, it is important to build successful relational systems to enhance organisational resilience (Kahn, Barton & Fellows, 2013). The bottom line is that to understand resilience in organisational systems requires realising that it is strongly related to social interactions, flow of information, organisational structures and their context (Amir & Kant, 2018; Kant & Tasic, 2018; Naim Kapucu, 2006; Sutcliffe & Vogus, 2003; Tasic & Amir, 2016; Weick et al., 1999).

Despite the considerable evidence social interactions, flow of information, organisational structures and their context affect organisational performance in normal and crisis conditions, there is a gap in understanding informational relations as well as multilevel organisational structures and management mechanisms, which affect social resilience. The capability to understand and manage those dynamics is a key to achieving and maintaining an expected level of social resilience. This gap is what this research aims to fill in. In this light, the dissertation empirically focuses on investigating different contexts to better understand social resilience and explore the ways to enhance it. The following sections of this research summary give an overview of the present study by highlighting research questions and objectives, methods, significance, and publications that comprise the thesis.

1.2. Research Questions and Objectives

To address the problem of social resilience enhancement, this dissertation raises three central questions as follows:

RQ1: How organisational interdependencies affect organisational resilience at multiple levels?

In management science, interdependencies are understood as social exchange relationships. It is a corollary of interactions that occur within and between organisational entities. The first question (RQ1) addresses the major challenge of understanding interdependencies. While it is already known that organisational interdependencies strongly affect the organisational performance, only a limited number of studies examined the consequences of multilevel interdependencies on the capacity for responding to disruptions. Therefore, the first research question investigates the multilevel relations between organisational interdependencies and organisational performance in normal and disrupted conditions.

RQ2: How can organised trust-based interactions, and information production and dissemination enhance disaster resilience?

On one side, people manage resources through social networks, which motivate them to take up collective action in a moment of crisis. On the other, another key factor in crisis management is information. Combining those two important factors in solving the second research question (RQ2), I aim to shed light on the impact of social interactions and information technology on enhancing disaster resilience.

RQ3: How can an organisation enhance its resilience capacity through multilevel management efforts?

Organisational complexity is made of multilevel resources. This entails that complex organisations require multilevel management efforts to remain resilient. Although researchers acknowledged that resilience is a dynamic process that rises at multiple levels, there has been a lack of studies that examined and addressed those challenges in theory and practice. To

address those challenges, answering the third question (RQ3) will advance resilience and crisis management research by the operationalization of the path that an organisation can take to enhance its resilience.

In sum, by answering the research questions, this research aims to:

1. Explore how organisational interdependencies are shaped at multiple levels and how they affect organisational resilience;
2. Examine the interplay between social capital and the use of information technology in crisis management;
3. Explore multilevel organisational processes and capabilities engaged in resilience and crisis management;
4. Provide a framework for enhancing organisational resilience;
5. Develop a model to examine organisational behaviour in times of crisis.
6. Give empirical evidences for: 1) how organisational interdependencies affect organisational performance in normal and disrupted conditions; 2) how organisational and social interactions and information technology contribute to community resilience; 3) how an organisation can enhance its resilience through self-assessment of its crisis preparedness and response capacity, and learning from the assessment results to strengthen its capabilities.

1.3. Methodology

To accomplish the research objectives in revealing how social resilience is shaped in different contexts, the research combines the advantages of qualitative (observation, interviews, document studies, open-ended questionnaire) and quantitative methods (social network analysis, agent-based modelling, closed-ended questionnaire) (Table 1).

Table 1. Research methods

Method	Research Question	Analysis
Observation	RQ3	<ul style="list-style-type: none"> 1-month observing and analysing an organisational context to design crisis simulation
Questionnaire	RQ1	<ul style="list-style-type: none"> Roster questionnaire to reveal formal and informal organisational structures
	RQ3	<ul style="list-style-type: none"> Close and open-ended questionnaires to investigate multilevel capabilities and simulate crisis response
Interview	RQ3	<ul style="list-style-type: none"> Open-ended interviews with senior staff on work culture, safety procedures, and relations with stakeholders and industry
	RQ2	<ul style="list-style-type: none"> Semi-structured interview with NGO volunteers on how crisis response was organised and which factors facilitated it
Document Studies	RQ3	<ul style="list-style-type: none"> Crisis operations procedures to assess crisis response correctness
	RQ2	<ul style="list-style-type: none"> Analysis of online data bases, social media posts, and maps
Social Network Analysis (SNA)	RQ1, RQ3	<ul style="list-style-type: none"> Multiplex and multilevel approaches
Agent-based Modelling	RQ1	<ul style="list-style-type: none"> Simulations of organisational system performance based on real-world data

Observation was conducted in a period of over 1-month and focused on analysing the organisational context to distinguish work as imagined from work as done. This information was useful to prepare the interview and questionnaires content (RQ3). *Document analysis* helped to prepare a stable research ground before the questionnaires and interviews design. The content analysis of online databases, social media posts, and maps was used to gain a comprehensive overview of the crisis management processes (RQ2). Crisis operations protocols were studied to understand the organisational operations in crisis conditions and assess the crisis response (RQ3). Both manifested and latent content of the documents was

analysed in order to organise information related multilevel mechanisms, capabilities, crisis response roles skills, etc. (coding categories), and draw the lessons to enhance organisational resilience. Semi-structured open-ended *interviews* with NGO volunteers were conducted to discover how crisis management processes were organised and which factors facilitated them (RQ2). Open-ended interviews with senior staff on organisational and environmental contexts (e.g. work culture, safety procedures and relations with stakeholders and industry) revealed some of the specifications that required deeper investigation in questionnaires (RQ3). *Questionnaires* were used to get both qualitative and quantitative overview of investigated organisational systems. Both open- and closed-ended types of questionnaires were applied. The closed-end questionnaires were utilised to 1) examine the formal and informal organisational structure, which provided input data for social network analysis and agent-based modelling (RQ1); 2) get quantitative overview of the individual (e.g. coping styles, psychometric resilience, mindfulness, task interdependence, and individual-organisation value congruence), and organisational capabilities (response role profiles, sociomaterial resources, organisational preparedness, average individual results, social interactions) (RQ3). Open-ended questionnaires were employed to investigate multilevel processes at individual, organisational and environmental levels, and simulate response to two crisis scenarios, i.e. a terrorist attack and “secret data loss” (RQ3).

Social network Analysis was used to build a model of organisational interdependencies, which comprised formal and informal relations within and between two organisations (RQ1). The model of interdependencies was constructed from the sociometric data gathered by roster questionnaires distributed in two collaborating organisations within a security services sector in Southeast Asia. The structure of multiplex interdependencies was mapped out and interdependence degrees at five organisational levels were calculated. Using the constructed model, *agent-based simulations* were conducted to investigate relations between organisational

interdependencies and organisational performance in normal and disrupted conditions (RQ1). The simulations highlighted two important aspects from the organisational systems functioning, i.e. task interdependence (agent had to cooperate with other agents to complete a task) and adaptation through collective problem solving (agents supported each other to solve a problem).

1.4. Research Significance and Contributions

Social resilience is a critical feature that allows effective mobilisation of accumulated resources and capabilities to overcome the unexpected disruptions. Given the paucity of understanding how social resilience is formed and enhanced, this research makes a significant contribution to scientific community by offering new theoretical and practical insights for resilience governance and crisis management studies.

1.4.1. Theoretical contributions

This study contributes to resilience and crisis management studies by introducing the new concepts and framework to be better able to examine 1) the influence of multilevel interdependencies on organisational resilience, 2) the impact of social interactions and informational technology on disaster resilience, 3) enhancing organisational resilience capacity through multilevel management efforts.

First, this dissertation introduces a new conceptualisation of multilevel interdependencies to better comprehend the complexity of social interactions in organisational systems. To this end, the research combines multilevel and social network theories to advance resilience and crisis management studies. More specifically, it focuses on how interdependencies emerge across multiple organisational levels, namely individual, intraunit, interunit, intraorganisational and interorganisational. The multilevel conceptualisation is bridged with resilience analysis by investigating relations between interdependencies and organisational performance in normal

and crisis conditions. The research results affirm that managing the complexity of multilevel interdependencies is crucial to reduce vulnerability of organisational systems and paves a path to strategic resilience enhancement.

Second, this research theorizes the interplay between social capital and information technology in building disaster resilience capacity. In particular, it offers the concept of informational capital, which refers to the amount of mutual trust and genuine participation in the production and dissemination of information in response to a disaster crisis. Combining the notion of social capital and information technology resources, informational capital emphasizes how information is produced, disseminated and perceived to be trustworthy by the community for crisis management. The concept is assessed through an in-depth analysis of three variables: 1) collective community features (type of culture common beliefs and values, community networks, participation, empowerment and trust); 2), individual members characteristics (hazard knowledge and awareness, skills, belief in community strength and spirit); 3) available information technology. The formation of the informational capital is showcased with the actions of Jalin Merapi, a web-based organisation formed to respond to the volcano eruption crisis.

Third, this research applies the multilevel approach to design a new resilience framework with which an organisation can self-assess its crisis preparedness and response capacity, and learn to enhance resilience. Resilience and crisis management theory is advanced by incorporating in the framework multilevel review of organisation's context, multilevel analysis of crisis response and multilevel learning processes. The framework underlines that crisis management and organisational resilience are mutually shaped across multiple levels. Focusing on individual, organisational and environmental levels, the framework shows in four phases how to enhance resilience through (1) reviewing and monitoring context, (2) testing preparedness,

(3) analysing and assessing response, and (4) strengthening capabilities. Mounting multilevel results leads to lessons that should be learnt at multiple levels to comprehensively increase organisational capabilities to cope with crises, and thus, enhance organisational resilience. In addition, the framework highlights that resilience management requires the continuous approach to embrace dynamics of organisational processes. The continuous approach allows a better monitoring of changes in internal and external organisational context, namely detecting weak signals and environmental pressures, and thus keeping awareness and sensitivity. It also enables verifying if the lessons developed in the past were actually learnt at multiple levels.

1.4.2. Practical contributions

The research provides a framework as well as suggests organisational practices and policy recommendations, which are expected to inspire organisations, communities, policy makers, planners, and government agencies and other practitioners in the development of more holistic strategies for resilience and crisis management to better cope with crises, disasters, and disruptions. The overview of practical implications of the dissertation is presented in the following paragraphs.

The empirical results of the conceptualisation of multilevel interdependencies in complex organisational systems imply that well-managed interdependencies are crucial to ensure resilient organisational performance. In line with that, the research offers several practical advices on how to design a resilient organisation. For instance, a resilient organisation should 1) aim to have the dense and strong of organisational interdependencies, especially at intra- and interunit levels (decentralising organisational structure, applying matrix model of the structure, nourishing organisational culture and environment); 2) have well-mapped both formal and informal organisational structures and incorporate them into its crisis management plans, procedures and practices (e.g. by acknowledgment of the role of informal leaders in

emergency preparedness activities); 3) have balanced amount of formal and informal interdependencies and stay aware of the differences and advantages of the two types of relations.

Drawing on the conceptualization of informational capital and its relevance to crisis management, there are several policy implications: 1) the presence of adequate information infrastructures is fundamental to allow communities to build emergent networks among themselves; 2) free flow of information among citizens needs to be widely available to support social access to the production and dissemination of information; 3) informational capital must be given an important place in disaster management in which information technology solutions for emergency warning systems have to be popularized and implemented; 4) the three types of social capital (bonding, bridging, linking) have to be strengthened to enhance community disaster resilience.

The empirical validation of the multilevel framework to enhance organisational resilience describes each of the application phases, i.e. it presents how the framework can be put into practice. Through the empirical validation, the framework has been proven to be a strongly valuable and flexible tool that allows an organisation to detect its vulnerabilities and increase its capabilities to improve its resilience. In this light, the framework highlights multilevel learning (organisational adjustment or transformation, crisis redefinition, environment stimulation) as an important next practice towards organisational resilience. More importantly, through practising responses and drawing the lessons, an organisation can expand cognitive, behavioural, emotional, relational, and sociomaterial perspectives, thereby upgrading inherent capabilities to respond to actual crisis. Furthermore, the framework takes the advantages of broad and workable application: 1) it can be used along with mix-method approaches that combine both qualitative and quantitative elements, and thus give more holistic analysis; 2) it

is able to detect various organisational vulnerabilities; 3) it can be employed to test organisational preparedness to different types of crises. Finally, resilience crisis and management practitioners will benefit from the framework as its application in different industries and organisational contexts will lead to building expanding a comprehensive base of methods to review and analyse multilevel elements, and sharing multilevel lessons.

1.5. Publications

This thesis comprises three self-contained research articles with relevant literature reviews:

- a) **Tasic, J.**; Tantri, F. & Amir, S. (2019). Modelling Multilevel Interdependencies for Resilience in Complex Organisation. *Complexity*.

This article aims to conceptualise and model multilevel interdependencies in complex organisational systems, and proposes the concept application for resilience analysis. Multilevel and social network theories are used to understand how interdependencies are shaped across organisational levels. Using the agent-based simulations, we investigate the relations between organisational interdependencies and organisational performance in normal and disrupted conditions. With the results, we show that managing multilevel interdependencies is crucial to reduce vulnerability of organisational systems. By introducing the multilevel conceptualisation of interdependencies and presenting their influence on organisational resilience, we pave a path to managing the complexity of interdependencies and strategic resilience enhancement in organisational systems.

- b) **Tasic, J.** & Amir, S. (2016). Informational Capital and Disaster Resilience: The Case of Jalin Merapi. *Journal of Disaster Prevention and Management*, 25(3), pp. 395-411.

The purpose of this paper is to present a concept of informational capital to explain the interplay between social capital and information technology in crisis management. The concept of informational capital revolves around the ways in which social capital and information act as crucial assets when a crisis strikes. Through informational capital, strong community bonds and ties are transformed into organised information that effectively facilitates collective action to face the emergency. This is evident in the role of Jalin Merapi, a web-based organisation formed to respond to the crisis.

c) **Tasic, J.**; Amir, S.; Tan J. & Khader M. (2019). Multilevel Framework to Enhance Organisational Resilience. *Journal of Risk Research* (in press).

This research paper introduces a multilevel framework to enhance organisation resilience. More specifically, we employ a multilevel approach to design a new framework with which an organisation can enhance its resilience through the self-assessment of crisis preparedness and response capacity. We highlight that crisis management and organisational resilience are mutually shaped across multiple levels, namely individual, organisational and environmental levels. We advance resilience and crisis management research by the operationalization of those levels that goes in four phases: (1) reviewing and monitoring context, (2) testing preparedness, (3) analysing and assessing response, and (4) strengthening capabilities. To validate the framework, we present an empirical study and describe the results to show how to utilise the tool in practice.

The following chapters (2-4) present three publication manuscripts. Two of them were published (Chapter 2 and Chapter 3) and one has been accepted for publishing (Chapter 4). They are reprinted with permission from co-authors. The papers have been also reformatted to preserve consistency in their presentation (uniform font styles and citation style, continuous numbering of figures, tables and appendices).

2. Modelling Multilevel Interdependencies for Resilience in Complex Organisation

Abstract

This paper aims to model multilevel interdependencies in complex organisational systems, and proposes its application for resilience analysis. Most of the existing research studied interdependencies only at the single-level and overlooked its multilevel character. In response to this gap, we propose a multilevel approach to better comprehend the complexity of interdependencies in organisational systems. More specifically, the study focuses on how interdependencies are shaped across multiple organisational levels. To understand the research problem, we use multilevel and social network theories to elaborate the concept at five organisational levels, namely individual, intraunit, interunit, intraorganisational and interorganisational. Further, we explain the application of multilevel interdependencies into analysis of organisational resilience. In particular, we construct a multiplex model of a real world organisational system that comprises formal and informal relations of different social exchange strength. Using the agent-based simulations of the organisational system, we investigate the relations between organisational interdependencies and organisational performance in normal and disrupted conditions. With the results, we show that managing multilevel interdependencies is crucial to reduce vulnerability of organisational systems. By introducing the multilevel conceptualisation of interdependencies and presenting their influence on organisational resilience, we hope to pave a path to managing the complexity of interdependencies and strategic resilience enhancement in organisational systems.

Keywords: agent-based model, complex system, crisis management, multilevel analysis, network analysis, resilience.

2.1. Introduction

What are the consequences of interdependencies that occur at multiple levels on our capacity for responding to disruptions? This paper examines the emergence of multilevel interdependencies and how they affect organisational behaviour in mitigating crisis. Organisational behaviours have their origins and consequences at different levels (House, Rousseau & Thomas-Hunt, 1995; Rousseau, 1985). In analysing this correlation, most management researchers study individuals, work groups, organisations, and industry using approaches in which the structure of interactions of these entities is typically observed only at one level (Hitt, Beamish, Jackson & Mathieu, 2007). Research conducted at the micro, meso and macro levels often ignores the fact that organisational dynamics results from multilevel interactions. This particular aspect is crucial in understanding the impact of interdependencies on organisational performance. In management science, interdependencies are understood as exchange relationships (Cohen & Arechavala-Vargas, 1987; La Porte, 1975) within and between organisations (H. C. Dekker, 2004). In general, studies on interdependencies are divided between those looking at the micro and meso level, and those at the macro one. Studies on the micro and meso interdependencies are firmly grounded in organisational behaviour and social science theories, which have been used to explain individual or group behaviour in the context of task interdependence, workflows, and interpersonal or intergroup relations (Kilduff & Krackhardt, 2008; Liden, Wayne & Bradway, 1997; Oh, Chung & Labianca, 2004; Tjosvold, Sasaki & Moy, 1998; Van Der Vegt, Emans & Van De Vliert, 1998). The macro approach has been usually adopted by economics, sociology, strategy, and supply chain management scholars. This approach provides the understandings of interorganisational relations between companies, supply chain partners, and regulatory and institutional entities that affect organisational performance (Alter & Hage, 1993; Barringer & Harrison, 2000; H. C. Dekker, 2004; Gulati, 1998; Provan et al., 2007; Shipilov, 2009; Tomkins, 2001). While single-level

approaches have their own virtues, there is a gap of knowledge in how these levels interact one another and what implications they bring on organisational resilience. Except the divergent focuses, research on interdependencies at single levels often uses structural-functionalism and social exchange theory lenses (Aiken & Hage, 1968; Brass, 1984; Burt, 1982; Granovetter, 1985, 1992; Roberts, 1989; Thompson, 1967; Tomkins, 2001) to investigate interdependencies. However, due to disparate goals, organisational experts of each of the levels have seldom merged their perspectives to achieve a bigger picture of organisational dynamics. As a result, adopting either a micro, meso or a macro lens only yields an incomplete understanding of multilevel interactions and their consequences. It is this lack of knowledge in multilevel organisational interdependencies that this paper seeks to shed light.

Grounded in *general systems theory* (Bertalanffy, 1969; Simon, 1973), a multilevel view on organisational analysis differs from analysing organisations through a single-level lens. It aims to shift the research field toward the view of organisations as complex and interconnected social systems (Katz & Kahn, 1978; Miller, 1978) where the phenomena are analysed at inter-level domains. Because interdependencies in organisational systems are too intricate phenomenon to be explained by only single-level terms, their comprehensive understanding requires integration of micro, meso and macro insights. Nowadays, due to economic and technological changes, the degree of interdependencies within and between organisations constantly grows (La Porte, 1996; Milch & Laumann, 2016). In this light, using the structural approach, we aim to introduce a preliminary conceptualisation of multilevel interdependencies in organisational systems and present its applications for resilience analysis. We elaborate the concept using the *multilevel* (Kozlowski & Klein, 2000) and *social network theories* (Borgatti & Foster, 2003; Kilduff & Tsai, 2003; Lazega & Snijders, 2016), which help us to explain in detail how interdependencies are formed and how they can be measured at each level. We argue that presenting interdependencies as a multilevel construct enables a more integrated and

comprehensive understanding of the phenomenon's complexity and dynamics that unfold across organisational levels, and affect organisational resilience. We prove it with agent-based simulations of a real organisational system under the crisis condition.

To achieve this objective, this paper is structured as follows. The following two sections present the state-of-art in interdependencies and resilience studies of organisational systems, in which we highlight the key aspects of interdependencies and resilience studies and identify areas where multilevel analysis remains lacking. After reviewing the existing works on organisational interdependencies and resilience, we begin to introduce a multilevel conceptualisation of interdependencies in complex organisational systems. We move then to the empirical application of the concept in the area of resilience analysis. More specifically, we construct a multiplex model of a real-world organisational system that comprises weighted formal and informal relations between and within two organisations. By giving the weights to multiplex relations we aim to reflect their different social exchange strength. We establish the weights based on the system of informal relationships introduced by Luo (2011), and the hierarchical logic of formal employment relationships, which determine chains of command (authority) and formal information exchanges (reporting) (Haythornthwaite, 1996). We also describe in details qualitative and quantitative characteristics of existing edges. Further, we present the relations between multilevel interdependencies and organisational performance in normal and disrupted conditions. Next, we discuss the results and highlight that managing multilevel interdependencies is crucial to reduce vulnerability and enhance resilience of organisational systems. The conclusion summarizes theoretical and empirical contributions of the paper.

2.2. Linking Interdependencies to Resilience

Interdependence began to be a subject of inquiry for organisational research in 1949 when Deutsch introduced a theory of social interdependence, which gained influences on management research and practices for several decades. Since then, organisation researchers have examined the nature and consequence of interdependence from various perspectives. A dichotomy between micro and macro levels appears to characterize the study of social interdependencies. In the micro studies of interdependencies, La Porte (1975) defined the degree of organised system complexity as a function of number of components, differentiation of components, and interdependent links between the components. In similar direction, management science explored interdependencies with the theory firmly grounded in organisational psychology and social science to explain human behaviour in the context of task interdependence, interpersonal relationships and performance at micro and meso levels of analysis (Kilduff & Krackhardt, 2008; Liden et al., 1997; Oh et al., 2004; Tjosvold et al., 1998; Van Der Vegt et al., 1998). At the macro level, analysis of interdependencies in management studies drew theoretical underpinnings on disciplines such as economics, economic sociology, and supply chain management to assess interorganisational relations that shape organisational performance, for instance, flows of goods and services, trust-based relationships, industry environment (Barringer & Harrison, 2000; H. C. Dekker, 2004; Gulati, 1998; Provan et al., 2007; Shipilov, 2009; Tomkins, 2001). In this area of research, only a few attempts looked into interdependencies across levels (Brass, Galaskiewicz, Greve & Tsai, 2004; Moliterno & Mahony, 2011).

In further developments of organisational sciences, interdependencies are understood as social exchange relationships (Cohen & Arechavala-Vargas, 1987; La Porte, 1975) within and between organisations (H. C. Dekker, 2004). At micro level, Brass (1984) underlined that an

organisation is composed of interdependent networks of employees. At meso level, the interdependencies are defined as a relationship between two or more organisational units that are mutually affected (Roberts, 1989). Following this path, Gulati (1995a) and Tomkins (2001) tracked down the source of interdependencies in the interorganisational context by focusing on the role of trust and information relations as determinants of the interdependent relationship. Conceptually, the notion of interdependence assumes at least one exchanged resource per interdependent dyad (La Porte, 1975). However, in real life, the relations become more complex, due to the multiplex types of independencies. It is extremely important to note that while organisational relations are *formally* maintained, through the existence of rules and regulations (Coleman, 1990; H. C. Dekker, 2004; Kogut, 2000), they are also *informally* shaped, through social structures, trust and reciprocity (Coleman, 1990; Granovetter, 1985; Ostrom & Walker, 2003). Informal relations embody interpersonal trust, which lubricates social support, and thus, enables complex transactions and facilitates collective action. Therefore, structural position of actor in an organisation is formed by both formal and emergent informal interdependencies, which interact with each other. In this area, interdependencies were analysed as networks of formal work exchanges (e.g. Brass, 1984; Mehra, Kilduff & Brass, 2001), and informal relationships as acquaintance, friendship and familiarity networks (Krackhardt & Hanson, 1993; Luo, 2011; Luo & Cheng, 2015). While the formal relationships are easily identified, the informal interactions are hardly detectable and often overlooked, however, they do impact on organisational performance (Flach, Carroll, Dainoff & Hamilton, 2015; Krackhardt & Hanson, 1993; Krackhardt & Stern, 1988; Rochlin, 1989).

There are two commonly distinguished types of ties—instrumental and expressive (Umphress, Labianca, Brass, Kass & Scholten, 2003). Instrumental ties are information and cognition-based exchanges of resources for instrumental purposes (e.g. reporting, acquaintance). Expressive ties include an affective factor and reflect common relationship

identity as well as social support (e.g. friendship). In addition, researchers also recognised existence of mixed ties, which combine features of both types (Luo, 2011). According to Luo (2011), informal instrumental ties are based on rules of equity (acquaintance), informal expressive ties are governed by rules of need (friendship), and mixed ties by rules of favour (familiarity). Both strong instrumental and expressive ties have a positive effect on performance; in contrast weak instrumental ties are less likely to enhance performance (de Montjoye, Stopczynski, Shmueli, Pentland & Lehmann, 2014).

Overall, the research on organisational interdependencies has produced a growing body of knowledge to illuminate the dynamics of organisational systems as a result of complex interactions and ever-expanding structures. However, as our review of this body of knowledge above indicates, most of the research is inclined to pay attention only at interactions and processes that occur at the same level. Characters and properties of interdependencies that emerge out of multilevel dynamics remain to be explored. In addition, the influence of informal interactions on organisational functioning requires in-depth analysis.

It is posited in this paper that the multilevel structure of interdependencies has potential impact on organisational capacity for responding to crisis, especially large-scale ones. What remains unclear is how exactly structural interdependencies will affect organisational resilience. To have a clear explanation, we first need to have a basic understanding of what constitutes resilience, and what renders organisation to be resilient. Up to date, the concept of resilience has been applied in a wide variety of academic fields, including, among others, ecology (Carl Folke, 2006; C. Folke et al., 2010; Gallopín, 2006), sociology (Adger, 2000), psychology (Ong et al., 2006), supply chain management (Sheffi & Rice, 2005), strategic management (Hamel & Välikangas, 2003), disaster mitigation (Paton & Johnston, 2017; Tasic & Amir, 2016), sociotechnical resilience (Amir & Kant, 2018; Kant & Tasic, 2018), resilience engineering

(Hollnagel et al., 2006; Nancy Leveson, 2004), organisational reliability (La Porte, 1996; Weick & Sutcliffe, 2011; Weick et al., 1999), and resilience management (Bhamra et al., 2011; Boin & Van Eeten, 2013; Heinemann & Hatfield, 2017). In the following lines, we describe the concept of resilience with a primary reference to resilience engineering and management studies, which constitute the most relevant ground for this paper due to their focus on social facet of resilience.

Many scholars acknowledge that resilience offers a potential solution to overcome disruptions and uncertainties in organisational systems, and create the environment for organisational development. In 2006, a group of experts in industrial and system safety initiated an organisation-centred paradigm called "resilience engineering" (Hollnagel et al., 2006). Recent, the continuations of those developments led to the following definition of resilience: "Resilience is an expression of how people, alone or together, cope with everyday situations – large and small – by adjusting their performance to the conditions (Hollnagel, 2017, p. 14). Resilience in the field of management is generally regarded as an emergent property of an organisation that relates to its inherent and adaptive qualities to mitigate risk (e.g. Burnard & Bhamra, 2011). In general terms, an organisational system is more resilient when it is more robust and recovers better from disruptions (Van Der Vegt, Essens, Wahlström & George, 2015). In line with the above state-of-the-art review, this study characterizes *resilient organisational system* as being proactive in mobilizing its resources and capabilities to effectively perform under a variety of conditions. Organisational resilience can be assessed through analysing of system performance (robustness and recovery) under different conditions that include both normal operations and disruptions.

How do organisational structures affect resilience? As pointed out by a number of researchers, complex systems organisations are composed of the multiple levels of operation (Comfort et

al., 2001) in which interconnected agents form a network of nonlinear relationships that give rise to emergent behaviours (Bhamra et al., 2011). The more complex organisation, the more complex response to disruptions will become (Comfort et al., 2001). Similar to safety, resilience is seen as a systemic property where individual, group, and organisational levels have a reciprocal influence on each other (Rioli & Savicki, 2003; Sutcliffe & Vogus, 2003). From this vantage point, managing resilience is “as a matter of a balancing between individual resilience (individual responses to operational challenges) and system resilience (the large scale autocatalytic combination of individual behaviour)” (Hollnagel et al., 2006, p. 88). Resilient employees and units do not guarantee resilient organisation. In addition, organisations are embedded in interorganisational relationship, which are crucial for sustaining their operations (Klibi et al., 2010; Provan et al., 2007; Sheffi & Rice, 2005). Organisations are more likely to be resilient if they can effectively mobilise internal and external resources and capabilities (Sutcliffe & Vogus, 2003). Therefore, interorganisational resilience is usually described as adaptability, flexibility and redundancy or diversification (Klibi et al., 2010; Sheffi & Rice, 2005). Applying *systems thinking approach*, Nancy Leveson (2004) argued that system safety is an emergent property, and thus must be controlled at the system level. Therefore, building resilience should be seen as a collaborative process, which requires continuous learning and adaptation from all actors, i.e. across individuals, groups, organisations (Heinimann & Hatfield, 2017; Martina K Linnenluecke, 2017) and interorganisational networks.

The bottom line is that organisational resilience is strongly related to everyday work and organisational structure (Amir & Kant, 2018; Naim Kapucu, 2006; Sutcliffe & Vogus, 2003; Weick et al., 1999). Well-developed relationships (formal and informal) within and among organisations are fundamental for taking up a joint action during normal and crisis operations (Krackhardt & Hanson, 1993; Krackhardt & Stern, 1988; La Porte, 1996; Weick et al., 1999).

The informal control instruments can substitute or complement formal control instruments in both normal (Granovetter, 1985; Jones, Hesterly & Borgatti, 1997; Poppo & Zenger, 2002; Rousseau, Sitkin, Burt & Camerer, 1998; Tomkins, 2001) and crisis operations (Krackhardt & Stern, 1988). Thus, any resilient organisational system has a strong culture of awareness, and is able to create improvised responsive networks to mitigate a crisis (Boin & Van Eeten, 2013; Krackhardt & Stern, 1988; Tasic & Amir, 2016; Weick et al., 1999).

2.3. Multilevel Interdependencies in Complex Organisation

Multilevel theory in organisational studies has its conceptual underpinnings in general systems theory (Bertalanffy, 1969; Simon, 1973), which presents organisations as complex and interconnected social systems (Comfort et al., 2001; Dooley, 1997; Katz & Kahn, 1978; Miller, 1978). Complexity of organisational systems arises from interdependencies of the system components and emergent behaviour (Sutherland & van den Heuvel, 2002). In this view, an organisation is conceptualized as a set of subsystems composed of more elemental components (Figure 1) that are arrayed in a hierarchical structure (Simon, 1973). Organisational systems are seen as tightly coupled and nonlinear structures blended with bidirectional causal loops (Meyer, Tsui & Hinings, 1993).

Figure 1. Nested character of complex organisational systems.

The main assumptions underlying the multilevel approach are that many phenomena emerge at multiple levels of analysis, and that organisational entities reside in nested arrangements (Hitt et al., 2007; House et al., 1995; Rousseau, 1985). The connection between levels of a system is determined by their couplings, which is the extent to which properties, dynamics, and processes at one level affect other levels (Simon, 1973). Partial analysis of the system can be misleading, and thus to avoid wrong conclusions multilevel analysis is extremely crucial to represent all properties of the system (Harary & Batell, 1981). The implication of the system approach is double-side. On one side, in line with general system theory, dynamics and relationships at lower levels emerge over time to higher levels of a system to yield structure (Cowan, Pines & Meltzer, 1994). This view coincides with theories of complexity, chaos, and self-organisation. On the other side, many organisational theories postulated that the contextual factors at higher levels may have direct or moderating effect on lower levels phenomena (Kozlowski & Klein, 2000). Although, we acknowledge that interdependencies, as many other phenomena in organisational systems, are a fuzzy concept that emerges bottom-up and is

affected by top-down contextual processes, in this paper our focus is primarily on the emergent character of interdependencies in order to open a research discourse on multilevel character of interdependencies.

In advancing multilevel interdependencies informed by the theoretical insights described above, we use *configural compilation approach* to analyse interdependencies as a multilevel construct (Griffin, 1997; Kozlowski & Klein, 2000; Meyer et al., 1993; Rousseau, 1985). The compilational approach rests on the assumption of discontinuity and complex nonlinear processes of emergence. It describes phenomena that comprise a common domain but are distinctively different as they emerge across levels, i.e. simple aggregation of a construct at multiple levels is impossible (Kozlowski & Klein, 2000). In compilation processes, concept properties across all levels are discontinuous—qualitatively different— yet functionally equivalent—have the same role (Rousseau, 1985). In this way, functional equivalence allows analysing a phenomenon by the elemental content of different types and amounts but possessing similar collective properties across levels (Morgeson & Hofmann, 1999). Configural properties of a phenomenon are based on compilation models of emergence, i.e. phenomenon is nonlinear, not uniformly distributed, and not isomorphic across levels. They capture the differential patterns of relationship and variability of lower-level contributions to yield higher-level properties. This means unit-level interdependencies are a complex configuration of unique characteristics of unit members that emerge as a whole. In sum, with application of configural compilation approach, we argue that interdependencies across all levels are discontinuous phenomenon that does not express uniform pattern due to their specific nature.

To further elaborate this concept, the *social network theory* (Borgatti & Foster, 2003; Borgatti, Mehra, Brass & Labianca, 2009; Kilduff & Tsai, 2003) is employed to explain in detail how

relational exchanges comprising interdependencies are formed in organisations, and to depict their pattern at various levels. The pattern includes both formal and informal structure of relations that form organisational systems. Formal relations are prescribed set of interdependencies between employees established by the organisation that determine its formal functioning, i.e. authority and reporting relationships. Equally important to underline are informal networks that comprise of trust-based relationships such as acquaintance, friendship and familiarity networks. These informal relations influence on individuals, group, organisation and interorganisational network performance (Cross & Parker, 2004; Gulati, 1995b; Mehra et al., 2001; Oh et al., 2004; Provan et al., 2007; Rochlin, 1989; Shipilov, 2009). In addition, informal organisational structure very often supplements the formal relations, especially in crisis situations (Krackhardt & Hanson, 1993; Krackhardt & Stern, 1988).

Applying the system view above, we recognise interdependencies to be nested at five organisational levels: *individual*, *intraunit*, *interunit*, *intraorganisational* and *interorganisational*. This span of levels represents a hierarchical structure in which each level represents unique characteristics of interdependencies between individuals, units, and organisations. The interdependencies at each level of representation are constituted by formal and informal relations. The interdependencies are coupled across levels and their content is meaningfully related in the whole network of relations. While lower levels such as individual and unit are composed of more elemental components, higher-level interdependencies, especially organisational and interorganisational, are relatively inclusive and encompass characteristics of lower-levels. In doing so, we assume that interpersonal interdependencies constitute individual interdependencies that contribute to intra- and interunit level interdependencies; intraunit and interunit interdependencies contribute to intraorganisational-level interdependencies (Figure 2).

Figure 2. Overview of nested multilevel interdependencies.

As elaborated above, each organisational system is a system of multiplex networks that comprises formal (reporting and authority), and informal (acquaintance, friendship and familiarity) relations, which form interdependencies across all levels of analysis. In the following paragraphs, we use weighted degree centrality to decompose and describe the multilevel interdependencies in organisational systems. Determining the weights depends on the particular analysis needs and the organisations features such as industry and organisational culture. In line with the configural compilation approach, the applied measures vary across the functional equivalents at multiple levels due to different characteristics of interdependencies across the levels (individual, intraunit, interunit, intraorganisational, interorganisational network).

1) *Individual interdependencies* entail formal and informal relational exchanges that constitute weighted degree of an individual, which is the focal point of analysis. Formal relations (F) comprise relationships predetermined by the organisation, i.e. authority and reporting relationships between the individual and other directly connected individuals. Formal weighted individual degree ($w_i^{[F]}$) is the sum of weights associated to all formal edges attached to individual i , where N is the total number of individuals in the interorganisational network m (Equation 1).

$$w_i^{[F]} = \sum_{\substack{j=1 \\ j \neq i}}^N w_{ij}^{[F]} \quad (1)$$

Informal relations (I) capture emergent organisational features and are the by-product of formal daily interactions and interpersonal attachment. They consist of trust-based networks, which influence on the work behaviour of the individual, i.e. acquaintance, friendship and familiarity networks (Luo, 2011; Luo & Cheng, 2015). Informal individual degree ($w_i^{[I]}$) is the sum of weights associated to all informal edges attached to individual i (Equation 2).

$$w_i^{[I]} = \sum_{\substack{j=1 \\ j \neq i}}^N w_{ij}^{[I]} \quad (2)$$

Formal and informal relations interact with each other and affect individual's behaviour. Therefore, the individual's structural position is the result of particular combination of both formal and informal interdependencies. The individuals bonded in the direct neighbourhood will be highly interdependent, and analysis of interdependencies at this level helps to assess individuals' connectedness.

2) *Intraunit interdependencies* emerge from the configuration of the unit members' interdependencies that give a comprehensive picture of interdependent relations within a unit.

The formal (F) and informal (I) exchange relationships remain the same features as at the individual level; however, the interdependencies are more complex due to the increased number of individuals and relationships. Formal intraunit degree ($w_u^{[F]}$) of unit u is the sum of formal edges attached to individuals within unit u , where K_u is the number of individuals in unit u (Equation 3). Informal intraunit degree ($w_u^{[I]}$) of unit u is the sum of weights associated to informal edges attached to individuals within unit u (Equation 4).

$$w_u^{[F]} = \sum_{i=1}^{K_u} \sum_{\substack{j=1 \\ j \neq i}}^{K_u} w_{ij}^{[F]} \quad (3)$$

$$w_u^{[I]} = \sum_{i=1}^{K_u} \sum_{\substack{j=1 \\ j \neq i}}^{K_u} w_{ij}^{[I]} \quad (4)$$

To allow the comparability of the unit structures between the units, we construct also the average formal ($\langle w_u^{[F]} \rangle$) and informal ($\langle w_u^{[I]} \rangle$) unit degree of a unit u (Equation 5 and 6), which are calculated by normalization of intraunit degrees by the number of individuals in a unit u .

$$\langle w_u^{[F]} \rangle = \frac{w_u^{[F]}}{K_u} \quad (5)$$

$$\langle w_u^{[I]} \rangle = \frac{w_u^{[I]}}{K_u} \quad (6)$$

Analysis of interdependencies at this level helps to identify the crucial individuals on whom the unit performance is the most dependent both formally and informally. Formal structure is always well known by the individuals involved in the unit. The analysis of informal structure helps to identify hidden unit patterns, and notice hidden needs and opportunities. Formal and informal relations should be well balanced to facilitate better the unit performance.

3) *Interunit interdependencies* encompass formal and informal relations that emerge from the cross-unit relations between individuals. Formal interunit degree ($w_{u_{int}}^{[F]}$) of unit u is the sum of weights of formal edges between individuals in unit u and individuals in other units (K_s) in organisation o , where U_o is the number of units in organisation o (Equation 7). Informal interunit degree ($w_{u_{int}}^{[I]}$) of unit u is the sum of weights of informal edges between individuals in unit u and individuals in other units (K_s) in organisation o (Equation 8).

$$w_{u_{int}}^{[F]} = \sum_{i=1}^{K_u} \sum_{\substack{s=1 \\ s \neq u}}^{U_o} \sum_{j=1}^{K_s} w_{ij}^{[F]} \quad (7)$$

$$w_{u_{int}}^{[I]} = \sum_{i=1}^{K_u} \sum_{\substack{s=1 \\ s \neq u}}^{U_o} \sum_{j=1}^{K_s} w_{ij}^{[I]} \quad (8)$$

Formal interunit relations determine how units operate and how much formally interdependent is their work. The units can be very independent (divisional structure), moderately interdependent (functional structure), or very interdependent (matrix). The informal relations, described in the social network theory as informal boundary spanning, emerge from informal interunit exchanges of information and support (acquaintance, friendship and familiarity relations). Informal interunit relations crucial for a unit to raise unit effectiveness and gain access to external resources; however, they work the best when the unit is well connected externally and well as internally.

We construct also the average formal ($\langle w_{u_{int}}^{[F]} \rangle$) and informal ($\langle w_{u_{int}}^{[I]} \rangle$) interunit degrees of a unit u (Equation 9 and 10), which are calculated by normalization of interunit degrees by the number of individuals in a unit u .

$$\langle w_{u_{int}}^{[F]} \rangle = \frac{w_{u_{int}}^{[F]}}{K_u} \quad (9)$$

$$\langle w_{u_{int}}^{[I]} \rangle = \frac{w_{u_{int}}^{[I]}}{K_u} \quad (10)$$

4) *Intraorganisational interdependencies* include formal and informal relationships within and between units of an organisation. Formal intraorganisational degree ($w_o^{[F]}$) of an organisation o is the sum of formal intra- and interunit degrees within this organisation (Equation 11). Informal intraorganisational degree ($w_o^{[I]}$) of an organisation o is the sum of informal intra- and interunit degrees within this organisation (Equation 12). The formal and informal intraorganisational degrees are crucial to assess internal connectedness of an organisation.

$$w_o^{[F]} = \sum_{u=1}^{U_o} w_{u_{int}}^{[F]} + \sum_{u=1}^{U_o} w_u^{[F]} \quad (11)$$

$$w_o^{[I]} = \sum_{u=1}^{U_o} w_{u_{int}}^{[I]} + \sum_{u=1}^{U_o} w_u^{[I]} \quad (12)$$

The average formal ($\langle w_o^{[F]} \rangle$) and informal ($\langle w_o^{[I]} \rangle$) intraorganisational degrees (Equation 13 and 14) are calculated by normalization of the degrees by the total number of individuals (L_o) in an organisation o .

$$\langle w_o^{[F]} \rangle = \frac{w_o^{[F]}}{L_o} \quad (13)$$

$$\langle w_o^{[I]} \rangle = \frac{w_o^{[I]}}{L_o} \quad (14)$$

5) *Interorganisational interdependencies* comprise formal and informal relations that emerge from the cross-organisation exchanges between individuals. Formal interorganisational degree

$(w_{o_{int}}^{[F]})$ is the sum of weights of formal edges between individuals in organisation o and individuals in other organisations (L_r) in interorganisational network m , where O is the number of organisations in the interorganisational network m (Equation 15). Informal interorganisational degree ($w_{o_{int}}^{[I]}$) is the sum of weights of informal edges between individuals in organisation o and individuals in other organisations (L_r) in interorganisational network m (Equation 16). Interorganisational relations constitute an important part of interdependencies as they may facilitate interorganisational information exchange, knowledge sharing, innovation transfer and support.

$$w_{o_{int}}^{[F]} = \sum_{i=1}^{L_o} \sum_{\substack{r=1 \\ r \neq o}}^O \sum_{j=1}^{L_r} w_{ij}^{[F]} \quad (15)$$

$$w_{o_{int}}^{[I]} = \sum_{i=1}^{L_o} \sum_{\substack{r=1 \\ r \neq o}}^O \sum_{j=1}^{L_r} w_{ij}^{[I]} \quad (16)$$

The average formal ($\langle w_{int}^{[F]} \rangle$) and informal ($\langle w_{int}^{[I]} \rangle$) interorganisational degrees (Equation 17 and 18) are calculated by normalization of the degrees by a total of individuals (N) in interorganisational network m .

$$\langle w_{int}^{[F]} \rangle = \frac{\sum_{o=1}^O w_{o_{int}}^{[F]}}{N} \quad (17)$$

$$\langle w_{int}^{[I]} \rangle = \frac{\sum_{o=1}^O w_{o_{int}}^{[I]}}{N} \quad (18)$$

2.4. Multilevel Interdependencies Model to Analyse Organisational Resilience

In this section, we bridge the multilevel conceptualisation of interdependencies with resilience analysis. More specifically, we present the application of conceptualisation to investigate the relation between interdependencies and organisational performance in normal and disrupted conditions. Based on the real world data, we construct an agent-based model of multilevel organisational interdependencies of two organisations. We demonstrate results of calculated interdependencies measures and performance simulations. The following research questions guided our analysis:

1. What type of structure makes an organisational system more resilient?
2. How does the degree of organisational interdependencies change at multiple levels?
3. Does higher degree of organisational interdependencies contribute to better performance?
4. Which of the interdependencies' levels contribute the most to the organisational performance?

2.4.1. Materials and methods

We used the agent-based method and built a model of organisational interdependencies, which comprised formal and informal relations within and between two organisations, which operate in the security services sector in Southeast Asia. The multilevel interdependencies can be measured in any organisational systems, regardless their size or operational context. We chose organisations based on the importance of their missions, and the potential impact of the study results on better managing interdependencies to ensure resilient organisational performance. Organisation A is as a research, training and operational support centre. Organisation B is an operational support centre to enhance well-being and operational effectiveness of another

organisation employees. Each of the organisations comprised 5 work units. The model of interdependencies was constructed from the sociometric data gathered in August 2017. The data was collected at individual level (N=54) by roster questionnaires that concerned six multiplex social networks: reporting relationships, authority, acquaintance, friendship, familiarity, and problem-solving (Table 2).

Table 2. Networks data used in the model

Social Network Questions	Relationships	Application in model
1. With whom do you like to discuss your daily work? (Luo, 2011)	Acquaintance (instrumental exchange)	Informal relations (trust-based)
2. With whom do you talk about your private affairs during your daily chats? (Luo & Cheng, 2015)	Friendship (expressive exchange)	
3. Suppose that your colleague asks you to help his/her friend. Whose friends would you help? (adapted from Luo (2011))	Familiarity (instrumental and expressive exchange)	
4. To whom do you report about you work progress?	Reporting (instrumental exchange)	Formal relations
5. Who is your direct supervisor?	Authority (instrumental exchange)	
6. Whom do you ask for help when you encounter a work-related problem, for which you couldn't find a solution yourself?	Problem-solving (instrumental exchange)	Task demand

Following the work of Haythornthwaite (1996); Krackhardt and Hanson (1993); Luo (2011); Luo and Cheng (2015); Soda and Zaheer (2012), the formal relations in the model consisted from reporting and authority networks, and the informal interactions comprised acquaintance, friendship and familiar ties. For informal relations only mutual links (links that were confirmed by both connected agents) were considered as reliable and included in the model. The multiplex model was specified by the vector of the symmetric adjacency matrices (undirected graph) of formal and informal relations: $A = \{A^{[F]}, A^{[I]}\}$. Each of the matrices was constructed through

the aggregation procedure that resulted in multiplex edge types, which allowed us to specify the simulation parameters (Appendix 1). The pairs of agents are connected by either 1) both formal and informal edges, or 2) a formal edge, or 3) an informal edge (Figure 3).

Figure 3. Multiplex model of organisational interdependencies. Nodes' colours represent work units. Node size depicts node strength. Blue and green edges are formal and informal relations. Individual no. 4 works in both organisations.

The strength of social exchanges was reflected in the weight values given to each type of formal and informal edges. Qualitative and quantitative characteristics of the edges are described in Table 3. The formal and informal weight values range from 0 to 1. The weights of informal edges are based on the system of social relationships introduced by Luo (2011) that governs complex social transactions dependently on proportions of instrumental and expressive

exchange dimensions. According to Luo (2011); Luo and Cheng (2015) the strongest and most efficient resource exchanges are facilitated through familiarity ties ('rules of favour'), succeeded by friendship ('rules of need'), and acquaintance ('rules of equity'). The weights of formal edges are aligned with the hierarchical logic of formal employment relationships reflected in an organisational chart, which determine chains of command (authority) and formal information exchanges (reporting) (Haythornthwaite, 1996). In this light, the authority relations, representing formal vertical relations, are defined as the strongest, and are followed by reporting relationships that include both formal horizontal and vertical relations. The weights of aggregated formal and informal links have been sums of single network weight values (e.g. an edge representing single reporting and authority has a weight equal to 0.8 which is a sum of 0.2 and 0.6).

Table 3. Quantitative and qualitative characteristics of existing relations.

Structure type	Edge types	Weight	Social exchange strength	Qualitative characteristics
<i>Formal</i>	One-way reporting	0.2	Weak	<ul style="list-style-type: none"> • Weak instrumental exchange • Limited reliability • No expectation of reciprocation • Occasional exchanges
	Mutual reporting	0.4	Moderate	<ul style="list-style-type: none"> • Moderate instrumental exchange • Moderate reliability • Expectation of reciprocation • Occasional exchanges
	Authority	0.6	Strong	<ul style="list-style-type: none"> • Strong instrumental exchange • High reliability • No expectation of reciprocation • Frequent exchanges

	Authority, One-way reporting	0.8	Very strong	<ul style="list-style-type: none"> • Strong instrumental exchange • Very high reliability • No expectation of reciprocation • Very frequent exchanges
	Authority, Mutual reporting	1.0	Extremely strong	<ul style="list-style-type: none"> • Strong instrumental exchange • Extremely high reliability • Expectation of reciprocation • Very frequent exchanges
				<hr/>
	Acquaintance	0.1	Weak	<ul style="list-style-type: none"> • Weak instrumental and weak expressive exchange • Moderate level of trust • Rules of fair exchange • Expectation of instant reciprocation • Limited reliability, often insufficient in obtaining valuable resources • Occasional exchanges
	<i>Informal</i>	0.3	Moderate	<ul style="list-style-type: none"> • Weak instrumental and strong expressive exchange • High level of trust • Rules of need • Expectation for reciprocation, but not instant • High reliability • Long-term, occasional exchanges (ad hoc when needed)
	Friendship, Acquaintance			<ul style="list-style-type: none"> • Moderate instrumental and strong expressive exchange • High level of trust • Expectation of reciprocation, but not instant • High reliability • Long-term, occasional exchanges

Familiarity	0.6	Very strong	<ul style="list-style-type: none"> • Strong instrumental and moderate expressive exchange • High level of trust • Rules of favour exchange • Expectation of reciprocation, but not instant • Very high reliability • Long-term and frequent exchanges • Strong enough to be a bridge to connect to other agents
Familiarity, Acquaintance, Friendship	≥ 0.7	Extremely strong	<ul style="list-style-type: none"> • Strong instrumental and medium or strong expressive exchange • High level of trust • Expectation of reciprocation, but not instant • Extremely high reliability • Long-term and very frequent exchanges • Strong enough to be a bridge to connect to other agents

Simulations

To investigate how structure of organisational interdependencies affects organisational resilience, we used the model to conduct series of simulations both in normal and disrupted conditions. The simulations highlight two important aspects from the organisational systems functioning, i.e. task interdependence (agent must cooperate with other agents to complete a task) and adaptation through collective problem solving (the agents support each other directly and indirectly to solve a problem). In all simulations, more than 80% of all agents are given tasks to complete. All tasks are specified by *tasks demand* [T_D], which is a list of resources that agent needs to gather to complete the task. The task demand was generated from the directed problem-solving network (Table 2) through selecting resources that belonged to the

agents connected by out-going edges (i.e. agents that an agent would contact if a work-related problem occurs). If the number of resources was more than five, only five resources were randomly selected, so the task demand lists ranged from one to maximum five resources. The task is completed when 100% of resources listed on the task demand are gathered (Algorithm 1). Each agent has a resource of his own (e.g. agent J has a resource J), and each network edge possesses a weight value that reflects strength of the relationship, as described in Table 3. The strength of relationship is reflected also in the parameter of speed, and thus, transfer time (Appendix 1, Table A.1.). The transfer time needed to connect and pass the resource between the agents is depended on the edge type. For each agent's step, the transfer time is calculated by subtracting the sum of formal and informal edges' speed values from 100. In each simulation we calculate the total time based on all transfer times needed to accomplish tasks to measure performance of agents, units, organisations, and interorganisational network. In the resources search, the agent use both formal and informal structure in the maximum distance of two edges. Based on social exchange theory, the agent will choose always the fastest way. To ensure the realism of simulations, the speed priority is given to all formal types of links (the most time efficient), so the agent will choose and informal edge only if there is no formal connection. In line with work of Luo (2011), the 2-step resource sharing is only possible when two conditions are fulfilled: 1) the first step edge is at least moderately strong informally (i.e. follows the rules of need or favour) or weak informally but the condition of instant reciprocation is fulfilled (rules of equity); and 2) the second step edge contains the familiarity component (rules of favour). In this case, the total transfer time is sum of all steps needed to share the resource (see more details in Algorithm 1 and examples in Appendix 2).

On the basis of the task demand lists, we create two types of *major work disruptions*: 1) targeted disruption (unavailability) of agents the most needed ¹ to complete the task demands (N=9, 20% of agents with tasks), and 2) random disruption of agents, which had a resource needed to complete at least one task demand (N=9, the same number of agents as in targeted disruptions). While in normal conditions, an agent, to complete his task, looks for a resource directly from the original resource (an agent who owns it), in disrupted conditions, the agents are allowed to use the substituting resources if the original resource is not available anymore (owning agent disrupted) (see Algorithm 1). The substituting resource is conditioned by existence of the edge type that comprises exchange of work-related information, i.e. reporting (formal relations) and acquaintance (informal relations). To create substituting resources we considered directed networks of reporting and acquaintance (only mutual links), in which incoming edges granted an agent 40% and 20% of substituting resource respectively. Thus, in case of simultaneous reporting and acquaintance incoming links, the maximum value of substituting resource in question is 60% (Appendix 1, Table A.1.). When we disrupt the organisational system, to complete his task, an agent first checks his available substituting resources, and next looks for other agents who can substitute the needed resource to reach the needed amount (100%).

¹ The agents with most demanded resources, i.e. agents with highest in-degree centrality in each unit. For bigger units at least 20% of agents were disrupted.

Input : *tasks, other_agents, networks, disrupted_agents*
Output : *agent_task_completion_time*
t = 0

```

1: for task in tasks do
2:   for other_agent in other_agents do
3:     if task = other_agent[resource] then
4:       if other_agent not in disrupted_list then
5:         task = 100%
6:         t + = transfer_time(other_agent, agent)
7:       else
8:         for subs_agent in other_agent[shared_resources] do
9:           if subs_agent not in disrupted_list then
10:            if distance(subs_agent, agent) = 1 then           ▷ 1 step
11:              agent[task] + = subs_agent[subs_resources]
12:              t + = transfer_time(subs_agent, agent)
13:            else if distance(subs_agent, agent) = 2 then   ▷ 2 step
14:              if link(1) and link(2) fulfill the 2-step rule then
15:                agent[task] + = subs_agent[subs_resources]
16:                t + = transfer_time(subs_agent, agent)
17: if all tasks ≥ 100 then
18:   return t
19: else
20:   return nan

```

Algorithm 1. Task completion and resource sharing.

In line with the theoretical approach applied in this study, resilience of organisational systems is assessed by analysing their performance under normal and disrupted conditions. Organisational system performance is measured by a number of completed tasks and time to complete the tasks. This method of measuring the system performance addresses important aspects of resilience (robustness and recovery) as well as organisational functioning (task execution).

2.4.2. Results

To answer what type of structure makes an organisational system more resilient, we examined the importance of formal and informal relations in determining the system behaviour under normal and disrupted conditions (Figure 4). We conduct simulations of systems including: 1) only formal relations (blue line), 2) only informal relations (green line), and 3) both formal and informal relations, i.e. the overall network (red line). Figure 4 presents average values from simulations of normal conditions ($n=1000$), random disruptions ($n=3000$) and targeted

disruptions (n=1000). We measure the system performance by number of completed tasks and time to complete the tasks. The simulations results showcase that organisational system with the overall structure (including formal and informal relations) performs better than the system, which has only formal structure or only informal structure. Importantly, the overall structure system performance is not a sum of formal and informal structures' performance. In this way, the overall system performance is not directly related to the number of existing links but rather their strength (relations quality) and other structural properties. Furthermore, it is crucial to acknowledge that in all conditions the formal structure plays a significant role in system performance, and the organisational system that possesses only informal structure cannot perform well. In normal condition, all tasks are completed in both systems, but the system with overall structure completes the tasks faster. In case of both disruptions, the performance of both systems drops, as some tasks cannot be completed. However, it is very important to highlight that during the disturbed conditions, informal structure complements the formal structure (by 8% and 15% in random and targeted disruptions respectively). More specifically, the informal structure supplements the unavailable formal connections, and this results in higher number of completed tasks as well as faster completion of the tasks. In sum, the organisational system with both formal and informal relations performs better, i.e. is more robust and recovers better, under normal and disrupted conditions, and thus, it is more resilient.

Figure 4. Performance of organisational structures in normal and disrupted conditions.

In addition, to rule out the factor of different links number and ensure the correct interpretation of the results, we have sampled formal and informal structures to have the same number of edges (precisely 90). In this way, we constructed the new overall structure that comprised 90 formal and 90 informal edges. We revised the task demand lists in accordance with the agents existing in the new overall structure. The new structures were sampled five times and simulations for the three conditions were repeated ($n=1000$, $n=3000$, $n=1000$). The average sampling results are presented in Figure 5. In general, the sampled results are consistent with the non-sampled (Figure 4). However, due to the executed changes that resulted in less efficient topology of new structures (smaller density, smaller transitivity, longer average path; see Table 4), we reported performance drop of sampled formal and informal structures in normal condition and random disruption. The performance drop was bigger in case of formal than informal structure, especially in normal condition. That was due to higher deteriorative discrepancy between the sampled and non-sampled formal structure in comparison to the sampled and non-sampled informal structure. In particular, the biggest disadvantages sampled formal structure concerned smaller transitivity, longer average path, and longer diameter, which highly influenced structure dynamics (see Table 4).

Figure 5. Average performance of sampled organisational structures in normal and disrupted conditions.

Table 4. Properties of non-sampled and sampled structures.

Structure	No. nodes	No. edges	Density	Transitivity	Average path length	Diameter
Non-sampled overall	54	217	0.15	0.44	2.66	2.40
Non-sampled formal	54	120	0.08	0.33	2.94	3.00
Non-sampled informal	43	97	0.11	0.43	3.40	3.90
Average sampled overall	53	180	0.13	0.38	2.81	2.66
Average sampled formal	52	90	0.07	0.24	3.31	3.76
Average sampled informal	42	90	0.1	0.39	3.42	3.76

In relation to the formal and informal structure, we investigated which types of edges facilitated most of exchanges in normal and disrupted conditions structure contributes the most to the organisational performance (Figure 6). The usage of all types was relatively stable in all conditions. In total, most of exchanges were facilitated by both formal and informal edges (on average 46%) or only by formal edges (on average 43%). Approximately 11% of exchanges were conducted by informal edges. Similar pattern was observed over the simulation time. These results highlight with more details and reiterate the important contribution of the informal structure to the organisational system performance in normal and disrupted conditions.

A) Used edges by structure type over simulation time

B) Used edges by structure type in total

Figure 6. Types of edges used in normal and disrupted conditions.

Next, we examined the values of the formal and informal interdependencies degrees at multiple levels (Appendix 3, Tables A-E). Table 5 presents the summarised results of the degree analysis. The higher levels of the analysis, the higher were the values of non-averaged degrees due to the increasing number of considered network elements and their complex nature. The non-averaged values of individual, intraunit, interunit, intraorganisational and interorganisational degrees ranged from 0 to 72.8, and the averaged degrees ranged from 0 to 5.5. While both formal and informal individual, interunit and intraorganisational degree values had moderate dispersion, the informal intraunit ($SD = 7.8$, $mean = 5.3$) and average formal interunit values ($SD = 1.6$, $mean = 1.4$) were characterised by high dispersion, that is the degree values were very widely distributed. As data concern the relations within one

interorganisational network, the variation at the interorganisational-level interdependencies was not possible to assess.

Table 5. Summary of interdependence degrees values at multiple levels.

Level	Interdependence Degree	N	SD	Mean	Max	Min
Individual	Formal individual	54	2.3	2.4	9.4	0.2
	Informal individual	54	1.7	1.9	6.6	0.0
Intraunit	Formal intraunit	10	6.8	7.9	25.2	0.4
	Informal intraunit	10	7.8	5.6	27.4	0.0
	Average formal intraunit	10	0.5	1.2	2.1	0.2
	Average informal intraunit	10	0.7	0.7	2.3	0.0
Interunit	Formal interunit	10	2.8	4.4	11.0	1.0
	Informal interunit	10	2.5	4.1	7.9	0.4
	Average formal interunit	10	1.6	1.4	5.5	0.2
	Average informal interunit	10	0.5	0.8	2.0	0.1
Intraorg.	Formal intraorganisational	2	11.4	61.4	72.8	50.0
	Informal intraorganisational	2	10.5	48.1	58.6	37.7
	Average formal	2	0.4	2.2	2.6	1.9
	Average informal	2	0.4	1.7	2.1	1.4
Interorg.	Formal interorganisational	1	0.0	0.0	0.0	0.0
	Informal interorganisational	1	0.0	2.7	2.7	2.7
	Average formal organisational	1	0.0	0.0	0.0	0.0
	Average informal organisational	1	0.0	0.05	0.05	0.05

The multilevel interdependence degrees are network centrality measures, i.e. rankings, which can be investigated by the Spearman's rank correlation coefficient ρ and the Kendall's rank correlation coefficient τ (Nicosia & Latora, 2015; Solá et al., 2013). Using the correlation coefficients, we examined if higher degrees contribute to the better performance, that is if there is a negative relation between formal and informal degrees and time to complete a task at multiple levels (Table 6 and Figure 7). We adjust the significance values applying the sequential Bonferroni method (Holm, 1979) to avoid inflated risk of Type 1 error related to

multiple comparisons. Subplots of Figure 7 are attached in the Supplementary Material for comprehensive image analysis. As each agent had a task that required different number of resources, each value of time to complete the task was normalized by number of demanded resources. In normal and random disruption conditions, there was a significant negative correlation between informal individual degree and time to complete a task, i.e. the higher informal individual degrees (Figure 7A) the faster task completion ($\rho = -.35$, $\rho = -.33$). Also, agents with higher formal individual degree tended to complete tasks faster in targeted disruption ($\rho = -.26$).

Table 6. Correlation between interdependence degrees and time to complete task.

Degree	Time to complete task(s)		
	Normal condition	Random disruption	Targeted disruption
Formal individual	-.024 (.000)	-.098 (-.055)	-.262* (-.193*)
Informal individual	-.351** (-.252**)	-.325* (-.239*)	-.174 (-.134)
Average formal intraunit	.058 (.068)	-.095 (-.023)	-.442 (-.295)
Average informal intraunit	.073 (.091)	-.085 (.000)	-.427 (-.273)
Average formal interunit	-.537 (-.432*)	-.463 (-.341)	-. 427 (-.250)
Average informal interunit	.450 (.270)	.316 (.180)	-. 377 (-.270)

Spearman's ρ (Kendall's τ)

Bold correlation values are significant at α level corrected by sequential Bonferroni method (Holm, 1979)

* $p < 0.001$ level (1-tailed); * $p < 0.05$ level (1-tailed)

At the intraunit level (Figure 7B), while in normal condition and random disruption there was no correlation between the formal and informal intraunit degrees and time, in the targeted disruption both average formal and informal intraunit degrees were moderately correlated with better performance ($\rho = -.44$, $\rho = -.43$). At the interunit level (Figure 7C), in all conditions, units with higher average formal interunit degree performed better, i.e. needed shorter time to complete tasks ($\rho = -.54$, $\rho = -.46$, $\rho = -.43$) than units with lower degrees.

A) Individual level degrees

B) Average intraunit level degrees

C) Average interunit level degrees

Figure 7. Relation between average interunit level degrees and task performance in normal and disrupted conditions.

At the intraorganisational level (Table 7), Organisation A with both higher average formal and informal intraorganisational degrees performed better than Organisation B, which had lower degrees. As the model concerns the only one interorganisational network, the relations between interorganisational degrees and performance was not possible to assess.

Table 7. Relation between average intraorganisational level degrees and task performance in normal and disrupted conditions.

Org.	Average formal intraorganisational degree	Average informal intraorganisational degree	Time to complete task(s)		
			Normal condition	Random disruption	Targeted disruption
A	2.60	2.09	126	118	122
B	1.85	1.36	145	134	157

There are three edge levels, which contain unique information about the organisational interdependencies, i.e. intraunit, interunit, and interorganisational. We examined their usage to assess which of them contribute the most to the organisational performance (Figure 8). In total, most of the organisational exchanges were facilitated through the intraunit (on average 62%) and interunit (on average 34%) edges. The interorganisational edges constituted only 4% of the total number of used edges. While, the usage of inter- and intraunit edges was stable in the normal and disrupted conditions, the usage of interorganisational edges decreased in the targeted disruption. This was due to the small number of interorganisational edges and low redundancy, which made this level prone to the disturbances caused in the targeted disruption.

A) Usage of edge levels over simulation time

B) Usage of edge levels in total

Figure 8. Levels of edges used in normal and disrupted conditions.

2.5. Discussion and Implications

Organisational interdependence is a multidimensional construct that can be conceptualised at multiple levels. On one hand, the interdependencies make an organisational system more complex (Milch & Laumann, 2016; Rijpma, 1997). On the other hand, the existence of multiplex relationships that comprise interdependencies is a natural feature of modern organisations (Ferriani, Fonti & Corrado, 2013; Shipilov, 2012). Because system's safety is an emergent property (Nancy Leveson, 2004), and partial analysis of the system can be misleading (Harary & Batell, 1981), it is crucial to have an in-depth understanding of the interdependencies' dynamics that happen at multiple levels. The analysis of structural properties of organisational

interdependencies helps to identify patterns, as well as assess needs and opportunities both in normal and disrupted conditions. By better understanding multilevel interdependencies we can reduce vulnerability and increase the ability to withstand dynamic changes, and thus, enhance organisational resilience.

Resilience is embedded in people's behaviour, and it is built by proactive approach to mobilizing resources, abilities to respond and perform under a variety of conditions. In this study, we view organisational resilience as a systemic property, which requires management of relational dynamics at multiple organisational levels. For that reason, the concept is highly relevant to resilience analysis in the organisational context. Our multilevel conceptualisation of interdependencies considered two dimensions of organisational relations—formal and informal—and proposed measures to investigate their structure across levels. With well-mapped organisational interdependencies, we can examine how an organisational system behaves under normal and disturbed circumstances. The empirical study proved the structure of interdependencies influences the efficiency of organisational performance. In the model, in line with the state-of-art literature (Liden et al., 1997; Tjosvold et al., 1998; Van Der Vegt et al., 1998), we highlighted that task interdependence affects the dynamics and outcomes of organisational relationships. The results showed that, an organisational system with a rich structure that combined both formal and informal relations performed better both in normal and disrupted conditions, thus was more resilient, than the system based only on the formal relations. The formal structure appeared to meaningfully contribute to organisational performance. However, our results also underlined the importance of informal structure that substantially complements and substitutes the formal structure, especially in the disrupted conditions. We showcased that the trust-based relationships strongly affect agent's decision-making and flow of network resources. The stronger informal relations, the faster transfer time and more resources are shared, as agents are more willing to help each other. In addition, in

most of simulated exchanges, the actors were connected by both formal and informal edge at the same time. These results confirm that well-established relationships (both formal and informal) within and between organisations condition organisational performance both in normal and disrupted conditions.

The analysis of introduced multilevel interdependence degrees can determine the organisation's ability to both work as expected, in normal conditions, as well as to create emergent response networks to confront the unexpected, mitigate consequences and adapt to the 'new normal'. The degree of organisational interdependence is not uniformed; rather it changes depending on the analysed relationship level. Facing the unexpected, task execution very often has to be changed and improvised due to unavailability of the needed resources. Individuals, units or organisations that normally are loosely coupled can be tightly coupled during a period of disruption. The interactions' changes happen at multiple levels, therefore, it is crucial to not only acknowledge the importance of individual interdependencies, but also higher interdependencies levels, such as intraunit, interunit, intraorganisational and interorganisational. Even though shaped by individuals' interactions, the higher-level degrees have unique features and provide new information that is crucial for resilience analysis of an organisational system. At multiple levels, the results showed there is a negative relation between the interdependence degrees and the time needed to complete a task. This was the most evident at the individual, interunit and organisational levels. Most of the simulated exchanges were facilitated through intra- or interunit edges, which at the same time contribute the most to the overall system performance. The analysis of the multilevel interdependence degrees indicated also individuals, units, and organisations are more structurally embedded in the organisational system, and thus, who potentially can benefit the most to organisational performance in normal and disrupted conditions, at the same time contribute to organisational resilience.

The results of this research imply that well-managed interdependencies are crucial to ensure resilient organisational performance. In the following lines, we present a few implications of this research. From our results, we can conclude that a resilient organisation should aim to have the dense and strong of organisational interdependencies, especially at intra- and interunit levels, which are constituted by the individuals' exchanges within the organisation. Some of the practices to reach this goal, could include 1) decentralising (flattening) the organisational structure, 2) changing the organisational structure to the matrix model, which imposes higher number of formal interactions between units, 3) nourishing organisational culture and providing environment that will help to activate formulation of new informal relations within and between units as well as strengthen the existing ones (organising social events, retreats, common spaces). Furthermore, both formal and informal organisational structure contribute to organisational performance during normal and disrupted situations, thus both of them should be part of in-depth analysis while establishing crisis management plans, procedures and practices. A resilient organisation should have balanced amount of formal and informal interdependencies, which can facilitate complex relational exchanges when the performance conditions are both certain and uncertain. The formal structure is very efficient in enabling the collaborative work, however, it is prone to the disruptions, and often it is the informal structure that supplements it during the disruptions. It is important to stay aware of the differences and advantages of the two types of relations. The analysis of informal structure can help to unmask concealed organisational patterns, needs and opportunities. This information can be used to eliminate hidden organisational vulnerabilities and use overlooked potentials. In practice, the strengths of informal structure could be recognised by acknowledgment of the role of informal leaders in emergency preparedness activities (e.g. drills and exercises), emergency response plans, contingency plans, and the business continuity plan.

This article aimed to introduce a new way of conceptualising organisational interdependencies and present its usefulness for resilience analysis. In particular, we showcased how multilevel interdependencies affect organisational resilience in a situation of major disruptions. We defined major disruptions as the condition when 20% of agents were not available. Although in this study we focused on the major disruptions in security services organisations, the concept of multilevel interdependencies remains relevant to investigate organisational resilience in case of disruptions of other size and type, and regardless the sectors. Furthermore, the constructed model can be extended to investigate other size of disruptions, and with modification of simulation settings it can be also applied to examine other types of disruptions. We encourage future research to modify our model or construct new models, which will showcase how multilevel interdependencies affect resilience in other types of disruptions. Due to the study focus and simulations design in which generalisation of findings to other size and type of disruptions as well as organisational contexts is limited, our analysis relates to major disruptions in targeted and random scenarios. The described application of the multilevel perspective on organisational interdependencies gave new insights on the structure of organisational interdependencies embedded in the specific context, which shapes the perceptions and behaviours of the involved actors. Future studies should consider cross-disciplinary analyses of the organisational interdependencies in other organisational contexts and larger samples in order to build up the comprehensive of how the interdependencies are shaped in different organisational systems and how they affect system performance. These future analyses, along with the preliminary results described in this paper, should be the insightful base of next practices for resilient design and management of organisational systems. Lastly, our analysis had limited focus on measuring the direct effects or causality between organisational interdependencies and organisational performance in

expected and unexpected conditions. Future research should take up the challenge to broaden analysis of the impact of organisational interdependencies on system resilience.

2.6. Concluding Remarks

Organisations are complex interdependent systems, which require management efforts to remain resilient. As noted above, we argue for correlation between resilience and organisational interdependencies. Interdependencies in organisations have been studied from various perspectives, however, most of the analyses were conducted only at the single level and overlooked the multilevel character of interdependencies. In response to this gap, we proposed a multilevel approach to better comprehend the complexity of interdependencies in organisational systems. With this paper we contributed to the study of interdependencies and resilience by introducing a multilevel conceptualisation of interdependencies in organisational systems, and presenting its application for resilience analysis. Adapting the most plausible definition of interdependencies as social exchange relationships, our paper sheds light on how those relationships are shaped across multiple organisational levels, and suggests how they could be decoupled in order to handle their complexity. We used the system and multilevel theories to explore five organisational levels, including individual, intraunit, interunit, intraorganisational and interorganisational. We argued that interdependencies are a discontinuous phenomenon across levels that does not express uniform pattern. Accordingly, we employed the configural compilation approach to describe interdependencies' features and proposed their measures at multiple levels. In addition to formal relationships, our conceptualisation underlines the significance of informal trust-based relationships, a notion that provides a new insight on the origins of interdependence. Furthermore, we applied the multilevel interdependencies conceptualisation into the analysis of organisational resilience, and presented the relations between interdependencies and organisational performance at

multiple levels in normal and disrupted conditions. Finally, we discussed how managing multilevel interdependencies is crucial to reduce vulnerability, and to build up, maintain and enhance resilience of organisational systems. By introducing the multilevel conceptualisation, we hope to pave a preliminary path to managing the complexity of the interdependencies in organisational systems. At the same time, we advance the analysis of the multilevel relationships between interdependencies and resilience as a promising step towards improving organisational design and resilience management.

3. Informational Capital and Disaster Resilience: The Case of Jalin Merapi

Abstract

This paper presents a concept of informational capital to explain the interplay between social capital and information technology in community-based disaster management. It aims to present a new concept of informational capital and highlights its key role in facilitating disaster management processes and contribution to community disaster resilience. The concept of informational capital revolves around the ways in which social capital and information act as crucial assets when a disaster strikes. Through informational capital, strong community bonds and ties are transformed into organised information that effectively facilitates collective action to face the emergency crisis. Based on an exploratory case study focusing on the 2010 eruption of Merapi volcano in Central Java, Indonesia, the paper seeks to analyse the emergence of disaster response fully organised by grassroots groups in Yogyakarta. In advancing the concept of informational capital, this paper analyses how the grassroots groups were able to mobilize resources for disaster relief, through which social capital became the foundation of community-based disaster mitigation, preparedness, response and recovery. Furthermore, the mobilization of social capital was significantly enhanced by mutual interactions facilitated by the use of information technology. This is evident in the role of *Jalin Merapi*, a web-based organisation formed to respond to the crisis after the volcano eruption.

Keywords: Informational Capital, Social Capital, Information Technology, Disaster Management, Disaster Resilience, Community Resilience, Volcanic Eruptions, Emergency Communications, Developing Societies.

3.1. Introduction

Understanding how communities respond to and recover from disasters is vital not only for governments, social scientists, and disaster researchers, but also for communities themselves. One key factor in disaster management is information. It is a crucial asset that defines the effectiveness of disaster management. This paper aims to shed light on the impact of information technology on disaster resilience. Specifically, this paper explores how information technology plays a key role in mobilizing social capital for disaster relief. It seeks to theorize the interplay between social capital and information technology in building disaster resilience capacity. To explain how social capital and information technology are inextricably intertwined in enhancing community disaster resilience, we offer the concept of “informational capital” a form of capital that we argue is able to improve practices in disaster governance. By bringing up the concept of informational capital, we hope to provide useful insights for community-based organisations, residents, local policy makers, planners and other practitioners involved in governance and reinforcement of disaster resilience capacity.

To advance the concept of informational capital, the paper draws on a case study located in Central Java, Indonesia. We specifically observe the formation of informational capital in the aftermath of 2010 Merapi volcano eruption that severely affected the local community. This paper is structured as follows. First, we present the concept of social capital and discuss its application in disaster management studies. Second, we highlight the meaning of information and information technology in disaster response processes, and formulate a new concept of informational capital. This is followed by a discussion of empirical evidence of the formation of informational capital in which its significant role in building the community disaster resilience is examined. The conclusion summarizes the characteristics of informational capital, and suggests policy recommendations for future disaster management.

3.2. Informational Capital: A Concept

To understand what we mean by informational capital, it is instructive to begin with a discussion of social capital. As a response to the shortcomings of “capital” by Marx (Marx, 1990/1867), the concept of social capital was introduced to assert that modern society is built and shaped not only by material conditions, but also by shared meanings formed by mutual interactions and cohesion, which are manifested in social networks. Putnam (2000, p. 19) refers social capital to “connections among individuals—social networks and the norms of reciprocity and trustworthiness that arise from them”. Social capital is considered to have many advantages for building mutual support, cooperation, organisational effectiveness, and even happiness. The core of social capital lies in trust. According to Coleman (1990, p. 307) “social capital is a system of mutual trust”. The research claims there are three types of social capital: bonding, bridging, and linking (e.g. Adger, 2003; Aldrich & Meyer, 2015; Putnam, 2000). *Bonding* social capital represents homogenous and emotionally close social groups featured with cohesion, trust, reciprocity, and adaptation (Adger, 2003). *Bridging* social capital is based on heterogeneous social groups open for new resources and attributed with high level of social trust and participation, which is usually referred to organizational membership (Aldrich & Meyer, 2015). A social network rich in bridging ties is a boundary spanning network (Bodin & Crona, 2009; N. Kapucu, 2006). Bonding and bridging are complementary (Putnam, 2000) and represent horizontal ties that connect people with the same social status (Aldrich, 2015). While bridging supplies the community with novel resources, bonding helps to absorb them (Newman & Dale, 2005). In turn, *linking* social capital stands for authority relationships (vertical bridging social capital), which connect regular citizens with the ones more powerful (Magis, 2010) and provides access to resources that normally are out of their range (Aldrich, 2015).

In further applications, researchers began to underline substantial importance of social capital in providing a basis for disaster management (Aldrich & Meyer, 2015; Pardasani, 2006; Tierney, 2014; Wilson, 2012). The capital-based approach in disaster management studies underlines societal resources as being necessary for proper community functioning in any emergency situation. This is because disasters devastate not only natural and physical environment, but also disrupt social fabrics in the affected area (Erikson, 1995). The concept helps to understand how people manage resources through social networks and what motivates them to take up collective action in a moment of emergency situation. Studies in this field reveal the importance of non-financial resources such participation, trust, self-help, emotional support, and sheltering (Tierney, 2014). Pre-existing connections between community members provide the community with critical level of resilience needed to withstand disaster crises. According to several researchers, communities with strong social capital are more likely to form community-based organisations and emergent community networks (ECN) (Bankoff & Bender, 2004; Birowo, 2012; Wisner, 2004). The emergent structures are either constructed as a new form of response to disaster, or they are transformed from the already existing social formations such as volunteers, neighbouring communities, rescue groups, aid provision groups, NGOs, etc. (Quarantelli, 2003; Tierney, 2014).

In the post-disaster response, the most crucial element is the production and dissemination of information, which is allowed by a high level of trust between information producers and information users, and available technology. As noted by a number of researchers, information is a key to taking actions in the time of crisis (Coleman, 1990; Dynes, 2006; Lindell & Perry, 2004; Sagala, Okada & Paton, 2009). During disaster crisis, a community often faces scarcity of information. Recently, the significant role of information technology in disaster management has been stressed by researchers (Birowo, 2012; Islam & Chik, 2011; Ryan, 2013). These studies describe how information technology reinforces efforts for disaster management

activities in order to reduce human and economic losses. Accordingly, informational capital responds to an urgent need for community to receive and access information necessary to understand and evaluate the crisis situation, prepare evacuation, distribute aid, etc. However, information itself does not guarantee executing an action. The accumulation of social capital is essential to take up collective action in order to response to the emergency situation. Social interactions, common beliefs, and values shape risk perception and decision making in the face of disaster hazards (Lavigne et al., 2008; Sagala et al., 2009). Thus, collective efficacy and community participation are necessary to develop adequate programs for disaster preparedness (Sagala et al., 2009).

It is in the interface of social capital and information technology that informational capital is introduced as a useful concept for disaster resilience. Informational capital refers to the mutual trust and genuine participation in production and dissemination of information facilitated by the use of information technology by a community in disaster management processes (Figure 9). System of mutual trust, i.e. social capital, is necessary for a community to take up collective action and build emergent social networks to respond to disaster. By reinforcing production and dissemination of trustful information, the information technology is essential to boost crisis communication, and thus, allows a community to better coordinate disaster management activities. In this light, the crisis communication depends on social collaboration and utilization of technology, knowledge and skills through a collective means. Combining the notion of social capital and information technology resources, informational capital emphasizes how information is perceived to be trustworthy by the community for disaster mitigation, preparedness, response and recovery. It can be assessed through an in-depth analysis of three variables. First, community features, such as type of culture (individualistic or collectivistic), common beliefs and values, level of trust (bonds), participation, community networks (collective efficacy), and empowerment (access to information, educational programmes).

Second, member characteristics in terms of hazard knowledge and awareness, skills, belief in community strength and spirit. And third, available information technology resources.

Figure 9. Fundamentals of informational capital and community disaster resilience

The main argument is that a community empowered by trustful social networks and information technology can better access to information, and is in a position to reduce harmful consequences of disaster. This is the core of informational capital, which plays a key role in enhancing community disaster resilience (see Figure 9). In the aftermath of disaster, informational capital accelerates and lubricates processes and mechanisms in communication, cooperation, and coordination carried out to assist affected groups and communities. Furthermore, informational capital links the community with accesses to various important resources of information such as updates on current situation, aftershock warnings, evacuation

instructions, distributions of relief aid, etc. Strong feelings of trust, dense and diverse social networks, community participation, and empowered access to information and information technology are the fundamental components of informational capital that in time increase preparedness, improve coping capacities, and minimize risk of misinformation and miscommunication. In sum, informational capital strengthens trustful exchanges of crisis information that enhance disaster resilience capacity of a community.

3.3. Mount Merapi

Java is the most populated island in Indonesia. Over 140 million people—around 56% of the country's population—live in the island. Having more than 40 active volcanoes renders Java the most volcanic island in the world. Specific geographic and topographic location of Java makes it prone to many kinds of natural hazards such as earthquakes, volcano eruptions, tsunami, landslides, etc.; in the last decade alone, several disasters have impacted the island. Standing at 2,965 m above sea level, Java's Merapi is one of the most active and hazardous stratovolcanos in the world (Surono et al., 2012). It is located in the northern part of the Yogyakarta Province, 25 km north from the urban area (Figure 10).

Figure 10. Topography of Merapi region. (Source: Google Maps 2015)

The modern record since 1548 shows that Merapi erupts regularly. Small-scale eruptions occur with average intervals of 4 to 6 years (Surono et al., 2012), and large ones every one or two centuries (Voight, Constantine, Siswoidjoyo & Torley, 2000). The 2010 eruption was the largest and the most explosive eruption of Merapi in the last century, triggered by tectonic movements in the region (Surono et al., 2012). The severe eruption process started on 26th of October 2010 and the high volcano activity continued for more than a month. The magmatic phase lasted 7 days and pyroclastic streams were ranging from 8 to 16 km (Surono et al., 2012). The eruption had a severe direct impact on area surrounding the volcano in the range of 30 km and resulted in damage and disruption of everyday life of the local community. The 2010 eruption claimed almost 400 fatalities and razed over 150,000 buildings, bringing an estimated loss of more than US\$300 million (Table 8). Approximately 400,000 people were evacuated

from the surrounding areas to refugee camps. The disaster severely struck the districts of Sleman (south flank), Magelang (west–southwest flank), Klaten (southeast–east flank), and Boyolali (northern flank) (GVM & IAVCEI, 2015). Pyroclastic flows and *lahars* (mud and debris flows) damaged hundreds of houses, many dams, bridges and roads (Surono et al., 2012).

Table 8. Summary of last Merapi activity and eruptions characteristics.

Year	Volcanic Explosivity Index (VEI)	Life loss	Characteristics and claimed damages
1994	2	66	Pyroclastic block-and-ash flows up to 7.5km Damage to villages and crops 6,000 evacuees
1997	2	6 missing, several injured	Damage to crops and a spring-water source Pyroclastic flows spread up to 4 km 5,000 evacuees
2001	2	2	Ash-falls covered the villages in 20km radius Pyroclastic flows extended up to 7km
2006	2	2	Pyroclastic flows and ash-falls up to 5km 14,000 evacuees
2010	4	386	Pyroclastic flows spread up to 16km Ash-fall was reported in the areas distanced up to 240km 150,000 buildings destroyed; 200,000 building damaged; 2,000 home destructions 400,000 evacuees Estimated loss of more than US\$300 million

Sources: GVM and IAVCEI (2015); GVP (1994, 1997, 2001, 2006, 2011, 2014); Subandriyo (2011); Thouret, Lavigne, Kelfoun and Bronto (2000); Voight et al. (2000)

Like many other Indonesian communities living in the shadow of volcano, the community of Mt. Merapi developed its own culture, based on mystical traditions, rituals, and beliefs in natural forces (Lavigne et al., 2008; Mei et al., 2013; Schlehe, 1996, 2008). With oral traditions and knowledge gained through direct experience with disaster, the community build up the capacity and adopted own ways to deal with the disaster (Dove, 2008; Lavigne et al., 2008;

Schlehe, 2008). Indeed, the volcanic culture influences on their disaster perception and the way they behave during the crisis (Dove, 2008; Lavigne et al., 2008; Schlehe, 1996, 2008). The traditional culture helps the community to build up coping mechanisms and provides spiritual disaster explanations (Lavigne et al., 2008; Schlehe, 2008). The spiritual volcanic culture of Merapi community represents informational capital in its traditional form, which differs from the modern concept of informational capital presented in this paper.

Perhaps not only because of its spiritual experience with the volcano, the community living at the foot of Merapi demonstrates a high level of disaster preparedness. There are also a number of social capital factors that facilitate disaster management processes (Birowo, 2012; Mei et al., 2013; Sagala et al., 2009), and which contributed to appropriate response to the 2010 eruption. According to Mei et al. (2013), the community of Merapi possesses very strong *bonding social capital*. The sense of collectivism, community values, solidarity, and harmonious life were deeply rooted in the everyday life of the community, which is predominantly Javanese ethnic. During the disaster crisis, the households with limited financial resources needed community assistance. Both physical aid (e.g. rebuilding houses) and emotional support of local community were significant for getting back to “normal”. Traditional community values encouraged people to help each other, especially under severe circumstances such as volcano disaster. One traditional value strongly shared by the community was “gotong royong” (loosely translated as mutual cooperation). Motivated by the spirit of gotong royong, community members helped each other to build refugee shelters in their private homes, which afterwards turned into solidarity refugee camps (Saputro, 2014). As a result, the community was able to properly respond to the disaster and to recover quickly. As explained by one of the volunteers:

“The spirit of gotong royong was very strong. It was the time for us to help others when they were in trouble—as the survivors who were displaced from their houses... We were highly motivated to help the victims, because we consider them our brothers and sisters, and we felt their pain.”²

Prior to the eruption, the community was already educated on volcanic hazards. An educational program for building capacity of the people living near the volcano was launched shortly before the 2010 eruption (GVM & IAVCEI, 2015). Many of the educational activities were organised in April and August of 2010 (Mei et al., 2013). Volcano Investigation and Technology Development Office (BPPTK), worked together with local government, research institutions and NGOs³ to give the community a series of training to improve their knowledge and awareness about natural hazards, and to build necessary skills to anticipate eruptions. The local community was even encouraged to participate in organising the educational programmes, which is crucial to build disaster capacity and response. This example of cooperation between the community and local authorities confirms existence of *linking social capital* and *community empowerment*. The results were significant, as well-organised disaster response activities, such as distribution of warnings, necessary information, and organising evacuations, saved between 10,000 and 20,000 lives when a disaster struck the area (GVM & IAVCEI, 2015). The role of community-based organisations should be emphasized because it bridged and linked social capital, especially in managing communication, and information production and distribution during the disaster crisis. The activity of Jalin Merapi Network deserves the highest attention.

² Skype interview with Ambar Sari Dewi, 29th April 2015

³ Some of the NGOs organising the disaster mitigation activities were part of Jalin Merapi Network

3.4. Rise of Jalin Merapi

Jalin Merapi Network (*Jaringan Informasi Lingkar Merapi*—Information Network Around Volcano Merapi) was founded in 2006, following the Bantul earthquake, a tragic disaster that killed almost five thousand people and caused a mid-eruption of Merapi. The network emerged as a bottom-up initiative of three community-based radio stations located around the volcano, two community radio networks, and four local NGOs (Saputro, 2016). Learning the lessons from the 2006 earthquake, and taking the advantages of information technology advancement, Jalin Merapi Network (JMN) supported also disaster response and recovery actions in the 2010 eruption.

There were two main strategic domains of the JMN activity: 1) production and dissemination of crisis information, and 2) support of disaster relief aid distribution. The decision to take a grassroots action was driven by, first and foremost, the spread of unreliable information delivered by mass media (streamed by authorities). They were also concerned with risk of unequal distribution of aid in which main refugee camps received more media attention while less visible areas suffered. This was exacerbated by a discrepancy between the aids and the true needs of the survivors. Facing this problem misinformation and miscommunication, the network sought to build reliable connections between survivors and donors from all over the country due to weak disaster management at local government level (lack of financial resources, lagging bureaucratic procedures) (Dewi & Nasir, 2012; Saputro, 2016).

To accomplish its goals, JMN carried out a set of activities as its main program. First, it aimed to deliver necessary and accurate information to the communities; second, it sent out reports on the real and immediate needs, especially from the areas with less media attention; third, it raised funds for relief aid; fourth, it built direct connection between donors and volunteers and refugees (in-person donation); and fifth, it gathered information about refugees conditions

(Dewi & Nasir, 2012; Saputro, 2016). Depending on activity they performed, volunteers were engaged into two types of functional groups, namely media centre operators and field volunteers (including information volunteers and citizen journalists) (Saputro, 2016). When the disaster struck, JMN launched an open call for volunteers and received 2,770 applications (Saputro, 2014). The selected information network of active volunteers comprised 700 active volunteers (Saputro, 2016), who were located around the Merapi. The volunteers operated 24/7 during the period of 1,5-month crisis. The volunteers decided to help because they simply felt this was the right way to do. Some of them experienced support of the network during the earthquake in 2006 and decided to pay back the debt. Ambar Sari Dewi shares her experience:

“When I saw people running for their safety, I told to myself—I have to help them... In 2006, when there was an earthquake in my region in Bantul, the people of Jalin Merapi helped me to rebuild our house and recover our environment. This was the time to repay.”⁴

Many of the volunteers originated from the volcano area and were closely connected to the local community (Saputro, 2014). Being part of the local community, JMN volunteers had deep knowledge of local context (topography, traffic conditions, volcanic ash distribution, etc.), shared with community strong cultural values and experience as well as personal and professional networks. This gave them advantage to easier gain mutual trust and build bonds with the survivors. According to Dewi, strong ties and bonds also deeply motivated Jalin Merapi volunteers.

While the media centre—together with the social media and hotline divisions—was located in Yogyakarta City, the field volunteers were placed in refugee camps where they gained direct

⁴ Skype interview with Ambar Sari Dewi, 29th April 2015

contact with the survivors and built trustful relationship (Saputro, 2016). The centre itself was responsible for coordination of all main activities of the network, i.e. compilation, validation and dissemination of information, placement of volunteers, and support of relief aid distribution. Since the primary mission of JMN was to bridge the information and relief aid from many sources, and to link them with the local communities suffering from the disaster, apart from the information received from volunteers placed in the refugee camps, there were many other sources such as community-based radio stations, donors, government agencies and general public. The information produced and disseminated by JMN was essential for disaster management decision-making on emergency coordination and aid distribution, and thus, it was crucial to deliver it as fast and accurate as possible. Although, the time plays an essential role in crisis communication and the speed of information delivery is a top priority, the quality of distributed information matters the most. Hence, before the dissemination, each produced communicate was cross-validated between the media centre, volunteer stations, JMN's data base, volunteer radio stations and public. To ensure best possible information accuracy, JMN used an interactive online spreadsheet that enabled multiple real-time information updates and validation at the same time. Some of the ways how information was verified include: 1) the media centre volunteers ensured that on-call information on demand from survivors and supply from donors was true (e.g. confirming that contact person exists and the request is valid); 2) field volunteers verified data on-site by visiting the survivor shelters; 3) public verification of the information available at the website, online spreadsheet, and social media accounts. In addition, there was also a strong feeling of responsibility related to the quality and accuracy of information, as explained by one key volunteers:

“We had to validate the information and make sure that the information is true because at that time Jalin Merapi was the only source in information for people and they relied on us. We did not want to disappoint them by sharing false and incorrect information.”⁵

It is worth noting that JMN was assisted with the information from government institutions responsible for volcano activity monitoring, national forces for search and rescue, humanitarian organisations, local government, and regional disaster management agencies⁶. This means the government was fairly in favour of the mission this grassroots network sought to complete. With continued support from government agencies, JMN was able to disseminate information on important issues, including current volcano conditions (situational reports based on visual observation of the peak), evacuation warnings and danger zone communicates, relief aid calls (what and where is needed, along with contact information).

Most of the dynamic and efficient information exchange was conveyed through Twitter accounts (in Indonesian and English). The presented snapshots of tweets provide the examples of information that was disseminated in the period of two weeks after the eruption had started, that is, when the crisis situation was the hardest:

a) Information on demand:

(Food, blanket, rice and medicine have been supplied to Srumbung post, but more donation is needed for school equipment and clothes)

⁵ Skype interview with Ambar Sari Dewi, 29th April 2015

⁶ Presentation of Jalin Merapi project: <http://bit.ly/21WVeTO>

b) Information on offered supply:

c) Information on transport:

(Requesting transport support to bring supplies to Cepogo BYL district that is lacking logistics)

d) Information on volcano conditions, forecasts, potential dangers and size of the evacuation zone:

(Warning about hot cloud and volcanic dust, which can reach a wide area because of wind. Appeal to use masks)

Indeed, information from volcano-monitoring institutions was trustworthy. However, it was insufficiently frequent and often failed to reach a majority of people in the remote areas. Besides, “the focus of the mainstream media and government were only on the Merapi activity instead of the needs of people who lived on the slopes of Merapi. These people were miserably neglected by mainstream media.”⁷ Hence, the network focused its activity on isolated and overlooked areas. The results were profoundly effective, as the local communities affected by the disaster confirmed that the information delivered by JMN was faster, more reliable and more relevant than the information shared by information outlets operated by the local governments (Saputro, 2014).

JMN utilized a range of different communication channels and a plenty of information technology tools to produce and disseminate information. These include live-streaming community-based radio stations, a website⁸, social media platforms (Twitter, Facebook), handheld transceivers, fixed and mobile phones, CCTV, and a seismogram (Dewi & Nasir, 2012). In fact, the JMN information services have been run by a local NGO,⁹ which since 2001 has supported community media development and utilization of information technology in the region. As we observe from the 2010 eruption, the use of information technology tools made immediate disaster response possible. Modern channels and techniques of information

⁷ Skype interview with Ambar Sari Dewi, 29th April 2015

⁸ JMN website: <http://merapi.combine.or.id/> (accessed 15 December 2015)

⁹ Combine Resource Institution website: <http://www.combine.or.id/>

dissemination, such as social networks and micro-blogging, brought a wider group of information receivers. JMN's social media accounts, especially Twitter and Facebook were followed by thousands of Indonesian netizens. Likewise, its website was frequently visited by information-seeking users per day. Thus, it constituted the main information hub. It was equipped with a livestream messenger, where live observations of the volcano were broadcasted everyday 24 hours. It also possessed a geo-tagging map with locations of volunteer groups, a real-time database with survivors' needs, a shoutbox, a SMS gateway, and an e-mail box. This combination of various media of information technology allowed general public to participate, contributing new information to the hub. Thanks to the close cooperation and mutual trust between locally-based Centre for a Research and Development of Volcano-related Technology (BPPTK), Radio of Republic of Indonesia (RRI) in Yogyakarta, and local community radios, real-time updates on the volcano status as well as information on disaster response activities were transmitted through radio channels (Saputro, 2014).

Apart from information production and dissemination, distribution of relief aid also constituted the core of program JMN activists were committed to. The main concern focused on the accuracy and relevance of aid distribution. The network coordinated supply and distribution of the aid in the form of basic goods (food, medication, sanitary detergents, basic equipment, animal's food, etc.), services (e.g. transportation), and financial support (bank and online PayPal transfers). The field information volunteers who were placed in the refugee camps gathered information from the survivors about what they immediately needed. This information was later relayed to donors and humanitarian organisations within and without Yogyakarta. An online database was available to show locations and items that were needed along with contact

information. The database updates were kept in real-time using a Google Docs spreadsheet¹⁰. In this way, donors were able to deliver the aid directly to the people in need, which profoundly shortened distribution time. The fact that many of the donors belonged to personal or professional networks of the survivors (Saputro, 2016), demonstrates how the bonding social capital of the Merapi communities was evident.

Although its operation to distribute information and to support disaster relief was successful during the 2010 response, it is by no means that JMN had not encountered problems. There were a few constraints that JMN had to overcome in terms of trust and legitimacy. Because disaster crisis information was commonly seen as a governmental domain, it did take some time for JMN to gain people's trust and to build up credibility. The key element in acquiring public trust was direct contact with the survivors, deep knowledge of local context, shared experience and cultural values, and high reliability of produced and disseminated information. Additionally, in order to strengthen the trust, JMN volunteers refrained from wearing uniforms or any recognisable badges, as these "official" symbols were not perceived well and would have created personal distance between volunteers and survivors.¹¹ As such, it created no boundaries between volunteer groups and disaster survivors. Due to its active response and reliability, JMN was able to appear legitimate to the government. As noted above, much of the information about the volcano status and disaster warning were received from governmental agencies. Officials from these agencies realized the important role of community-based organisations such as JMN played in making disaster relief more effective. As a matter of fact, JMN was considered a partner by the provincial disaster management agency due to its ability to distribute information and aid directly to those affected by the disaster. Such a conducive

¹⁰ Google Docs spreadsheet: <http://bit.ly/1MokKbp> (accessed 2 March 2019)

¹¹ Skype interview with Ambar Sari Dewi, 29th April 2015

environment for JMN to cooperate with government agencies is not uncommon. After the end of the New Order authoritarian regime, the role of grassroots organisation in many sectors of development became prominent due to realizing that the government has a limited capacity to handle complex issues in the society. Certainly democratization has opened up new possibilities for civil society groups to contribute to public services, including disaster mitigation (Nyman, 2006).

Aside from trust and legitimacy, technical and financial constraints were also present. For instance, after creating a Facebook account and discussion groups¹² the activity on the JMN account rose quickly. Such high activity was notified by the provider as malicious behaviour, resulting in security suspension of one of the discussion groups. Fortunately, JMN was able to overcome the issue by creating new groups and distributing members in accordance with a discussion topic. Another constraint was a lack of PayPal account, which is necessary for receiving international transfers. This issue was solved when a foreign student came to offer help to set up an account. Furthermore, JMN met another dilemma regarding information validation in which the speed of information delivery and accuracy were against each other. In any case, the delivery time was considered to be more important. This was resolved by an interactive platform in which information inputs are subject to multiple-validation by members of the network such to avoid incorrect and false information affecting disaster relief process. Finally, manpower and financial limitations, to some extent, affected the operation of JMN, especially after the situation became normal and volunteer students went back to school. That meant much less field volunteers were available to help. As the media centre was maintained

¹² At that time each discussion group could have just 250 members.

by a local NGO, financial support was substantially limited and eventually finished in the end of the year (Saputro, 2014).

Despite these constraints, JMN was able to make significant contribution to the disaster relief in the aftermath of the 2010 Merapi eruption. The activities of this information technology-based network shows how informational capital exercised by JMN had substantial impacts on community disaster resilience. We will discuss this issue in the following section.

3.5. Disaster Resilience

From what we have discussed above, the communities living at the foot of Merapi exhibited remarkable signs of resilience to the 2010 eruption. As argued in this paper, the community disaster resilience was in part due to *well-developed informational capital*. The informational capital was introduced in its modern and unique preface, which, as mentioned, differs from the traditional one, grounded on spiritual volcanic culture of Merapi. More specifically, apart from its coping advantages; the traditional informational capital brings also potential risk underestimation (Dove, 2008), subjective feeling of security (Schlehe, 2008), and the blind belief that the disaster can be mitigated through spiritual activities (Schlehe, 1996). In contrast, through the unique activity of JMN, the modern concept of informational capital has been presented as strong social capital reinforced by powerful proprieties of information technology.

The bottom line is that the emergent structure of JMN came from pre-existing *social capital*, which was manifested in community disaster resilience capacity when combined with a proper utilization of *information technology*. JMN was founded in response to misinformation, miscommunication, and risk of unequal distribution of disaster aids. Through realizing its two main strategic domains of activity, i.e. 1) production and dissemination of crisis information, and 2) support of disaster relief aid distribution, JMN filled the disaster management gap and

greatly contributed to building community disaster resilience. The information produced and disseminated by JMN concerned on important crisis issues such current volcano conditions (including situational reports based on visual observation of the peak), evacuation warnings and danger zone communicates, relief aid demand and supply. To fulfil JMN mission, the volunteers utilized a wide range of information technology tools and communication channels, such as website, social media platforms (Twitter, Facebook), geo-tagging maps, online spreadsheets, live-streaming community-based radio stations, mobile phones, SMS warnings, CCTV, etc. Importantly, JMN volunteers built and strengthened mutual trust relationships with the survivors, and thus, they were able to effectively disseminate information and help in aid distribution for disaster relief. In this manner, the informational capital bridged affected communities with external resources, which were crucial for proper disaster response and recovery. In addition, it is also important to highlight that JMN volunteers also highly contributed to organising disaster mitigation and preparedness activities such as educational programmes and trainings, which empowered local community with knowledge and awareness about natural hazards before the disaster happened. In this way, JMN played important role in building and enhancing community disaster resilience. The results of this well-organised disaster mitigation, preparedness, response saved between 10,000 and 20,000 lives (GVM & IAVCEI, 2015), and allowed quick recovery. Our analysis highlights the following components of the informational capital as playing an essential role in building resilience: strong community bonds and mutual trust, community empowerment and disaster awareness, emergent network cooperation (collective efficacy and participation), effective real-time monitoring, quick and reliable production of information and dissemination as well as well-organised distribution of aid facilitated by information technology.

As highlighted in this paper, strong social capital is the basis of informational capital. This means it is important for a community to have proper amount of bonding, bridging and linking

social capital prior to the crisis. The Merapi communities had developed all three types of social capital (Figure 11), which allowed them to create a powerful emergent community network that assisted disaster management processes. The strong *social bonds* promoted trust, shared values, and reciprocity gave the community members the feeling of community cohesion, belonging, and in the time of crisis stimulated mutual help, adaptation, and absorption of the bridged resources.

Figure 11. Types of social capital engaged in the 2010 Merapi eruption¹³

Bridging ties motivated and encouraged the communities to initiate collective action for facilitating the flow of new resources needed for disaster relief, which essentially gave rise to

¹³ This is a conceptual model of the JMN ties. In order to maintain transparency of the network some of the actors and ties are omitted.

JMN. The network embodied both strong bridging social capital and strong linking capital (also called vertical bridging social capital). Interestingly, for its rich of bridging ties, we found JMN as a boundary-spanning network. Therefore, it comes as no surprise that JMN was able to foster the information and aid flows in previously unconnected communities. Equally important is the fact that JMN contributed to building the feeling of *mutual trust* indispensable to take up collective actions. The individuals constituting the group originated from all walks of life. They came from different backgrounds, including local communities, local governmental offices, civil society organisations, research centres responsible for monitoring volcano activities, safe and rescue forces, humanitarian organisations, academic researchers, etc. The actors were tied together in the *empowered emergent network*, allowing them to work together to fulfil the common mission. The presence of JMN allowed these groups to gain strategic links to cooperate with various actors and to use their help and resources. In this view, JMN represented strong *linking social capital* by integrating heterogeneous actors and leveraging network resources that were beyond the community range.

In a time of crisis when the level of uncertainty grows and urgent needs come about, new *emergent community networks* and organisations will arise. According to Dynes (2006), emergent structures connect elements of community structure together to fulfil new tasks and take up collective action. Furthermore, they emerge when traditional structures are insufficient or incapable to respond to a crisis. These emergent organisations tend to be flat, organic, and task-oriented with a goal to solve *ad hoc* problems (Quarantelli, 2003; Stallings & Quarantelli, 1985). As we observe, these are exactly the striking features of JMN as it performed the characteristics of emergent structures in response to inadequate information dissemination, inefficient information production and relief aid distribution, unreliable infrastructures, and weak disaster management at local government level. The network activities were concentrated on realization of specific tasks to respond to the crisis situation. The organisational structure of

JMN was considerably flat, which resulted from non-hierarchical relations built by the pioneering actors (Dewi & Nasir, 2012; Saputro, 2014). The distribution of organisational authority follows the functional division, consisting of two types of volunteer groups. This is because most of the tasks needed to be performed at hand, as the disaster situation was highly dynamic and uncertain.

As has been studied by many researchers, information is an important asset during the disaster crisis and a crucial element of resilience (Dynes, 2006). However, it is not enough to deliver the information. A high level of trust between the producer and the user is required to ensure reliability of messages circulated during a crisis. Only social networks with mutual trust are able to effectively disseminate information for disaster relief. Having sufficient amounts of informational capital that came from trustful social networks and utilization of information technology, JMN was able to contribute to strengthening resilience of the Merapi community. Through direct contact in the affected area, JMN's field volunteers built the relationship and bonds with the survivors, which became the basis for mutual trust. Furthermore, the information messages disseminated by JMN were always as much fast, clear and accurate as possible. Each volunteer typically possessed adequate knowledge of the local specifics (topography, volcanic ash distribution, traffic conditions, local people beliefs etc.). In this way, JMN appeared to be the most efficient in supporting the local communities at the moment of disaster crisis. With its accumulated informational capital, JMN proved to have made significant contributions to disaster response and recovery during the 2010 Merapi eruption, enhancing resilience of the community in an unprecedented way.

3.6. Concluding Remarks

Today JMN is still running as an active group that seeks to contribute to reducing disaster risks for the people in Yogyakarta and the surrounding areas. It has now evolved into a more stable

organisation with continued support from local and non-local communities. Information technology remains the core infrastructure of JMN with a growing number of community-based radio stations located around the volcano joining the network. Furthermore, JMN develops further cooperation with various agencies and organisations in order to broaden the spectrum of actors and participants to deliver more comprehensive information to the Merapi community.

As argued in this paper, what JMN has accomplished exemplifies the formation of informational capital, which is embodied in the production and dissemination of information to respond to a disaster crisis. Furthermore, we have highlighted how informational capital is formed by social capital and information technology in facilitating disaster management processes. Analysing the catastrophic event, we have underlined the critical functions of community networks, collective action, trust and empowered information access in disaster mitigation, preparedness, response and recovery. The case study also shows how informational capital is potential to enhance community network and information access, and boosts community capacity for disaster response.

Although the concept of informational capital is sufficiently introduced in the preceding sections, it certainly requires further elaboration beyond what is examined in this paper. Our goal here is to present a preliminary conceptualization of informational capital as a key factor in disaster resilience. Hence, we would like to encourage further research on informational capital. Future studies should continue to tease out the ways in which informational capital facilitates community disaster resilience at broader scales and in more complex situations. In addition, worth exploring are new approaches to assess and measure the impact of informational capital on building disaster resilience at different levels.

To conclude this paper, we identify several policy implications drawing on our conceptualization of informational capital and its relevance to disaster governance. First, the presence of adequate information infrastructures is fundamental to allow communities to build emergent networks among themselves. Second, free flow of information among citizens needs to be widely available to support social access to the production and dissemination of information. Furthermore, informational capital must be given an important place in disaster management in which information technology solutions for emergency warning systems have to be popularized and implemented. Moreover, the three types of social capital have to be strengthened to enhance community disaster resilience. Bonding social capital has to be preserved by promoting social cohesion, solidarity, and protection of community common spaces. Bridging social capital, embodied in emergent community networks, has to be recognized and empowered in disaster risk reduction policy. Finally, linking social capital should be pursued through building mutual trust between government and community, and promoting public participation in disaster governance.

4. A Multilevel Framework to Enhance Organisational Resilience

Abstract

The multilevel character of organizations has been generally acknowledged in existing organizational studies. However, there is a lack of theoretical and empirical studies in organizational science that address this specific aspect and how it can affect organizational resilience. In response to this gap, this paper introduces a multilevel framework applicable to enhance organization resilience. More specifically, we employ a multilevel approach to design a new framework with which an organization can enhance its resilience through the self-assessment of crisis preparedness and response capacity. This process will allow the organization to reduce potential vulnerabilities in the interaction between its organs as well as environment. We highlight that crisis management and organizational resilience are mutually shaped across the multiple levels, namely individual, organizational and environmental levels. We advance resilience and crisis management research by operationalization of these levels in four phases: (1) reviewing and monitoring context, (2) testing preparedness, (3) analysing and assessing responses, and (4) strengthening capabilities. In these phases, we underline that resilience management based on the proposed framework requires continuous embracing of the dynamic processes within an organizational system and its environment. To validate the framework, we present an empirical study on a security organization, and describe the results to demonstrate how to utilise the tool in practice. Finally, we discuss the advantages of the multilevel framework as a promising path towards building stronger resilience management.

Keywords: resilience, crisis management, multilevel analysis, organisational learning.

4.1. Introduction

How can organisations enhance their capacity for responding to crisis in the increasingly complex world? Today's organisations inevitably face more frequent and greater crises (Williams, Gruber, Sutcliffe, Shepherd & Zhao, 2017) that threaten their continued functioning and performance. Crisis management and resilience research from a variety of disciplines has sought to explain why crises occur (S. Dekker, 2011; Perrow, 2011; Pidgeon & O'Leary, 2000), how organisations respond to crises (Weick, 1993; Weick et al., 1999), and how organisations can prepare for crises and mitigate their negative consequences (Boin & Van Eeten, 2013; Comfort et al., 2001; Hollnagel et al., 2006; N. Leveson et al., 2009; Sutcliffe & Vogus, 2003). Many substantial contributions were derived from extreme events such as terrorist attacks (Colville, Pye & Carter, 2013), fires (Weick, 1993), space shuttle explosions (Vaughan, 1996), nuclear meltdowns (Amir & Juraku, 2014; Funabashi & Kitazawa, 2012), and natural disasters (Martina K. Linnenluecke, Griffiths & Winn, 2012; Tasic & Amir, 2016). Despite its rich fundamentals, crisis management research still overlooks to use the opportunities of cross-disciplinary perspective (Boin, Comfort & Demchak, 2010; Bundy, Pfarrer, Short & Coombs, 2017; Williams et al., 2017). The quality of crisis response depends on the organisational capacities related to resilience, i.e. improvisation, coordination, flexibility, and endurance (Boin et al., 2010). However, even though crisis management and resilience are intrinsically related, there were only few attempts to consolidate the research of those two domains (Williams et al., 2017). Further, most of the crisis management studies missed the integrative multilevel opportunities focusing on individuals, organisations, and institutional environment separately. Therefore, only little has been known on how the interactions of individual, organisational, and environmental factors influence the crisis management and resilience processes (Bundy et al., 2017). Similarly, resilience emerges from interactions of factors

located at different levels that evolve over time, and thus its analysis requires a multilevel and dynamic perspective (Van Der Vegt et al., 2015, p. 977; Williams et al., 2017).

Organisations can avoid and better respond to crises by adjusting their culture and structure (Bundy et al., 2017). Crises can be low-probability triggering events or by-product of cumulative ignorance of weak signals and detrimental work practices. Resilience is about preventing organisational weakening, responding to crisis, as well as adjusting and recovering from it. Resilience is not static, but rather continuously developed, and sometimes undeveloped over time (Boin et al., 2010; Sutcliffe & Vogus, 2003). Organisations operating in the risky contexts, high reliability organisations (S. Dekker & Woods, 2010; Weick et al., 1999), such as blue light services, government security agencies, have to persistently work on their resilience (Hällgren, Rouleau & De Rond, 2018). Despite the constant uncertainty, those organisations have to perform reliably (Weick, 1993; Weick & Sutcliffe, 2011; Weick et al., 1999). In order to do that, they need to constantly keep situational awareness to emerging threats, act swiftly, and treat safety as operational priority. Although resilience theory has been growing over the last two decades, empirical studies have been scarce (Van Der Vegt et al., 2015). Nevertheless, analysing crisis responses to extreme events may provide rich insights into organisational processes, vulnerabilities, and resilience (Hällgren et al., 2018; Lampel, Shamsie & Shapira, 2009). The results of empirical studies are indispensable to build better models particularly for decision makers to improve organisational capabilities to cope with crises.

In response to the above-mentioned gaps, drawing on prior research on crisis and resilience, we propose a multilevel framework for enhancing resilience in organisational systems. The framework addresses the following theoretical and practical challenges: 1) What are the individual, organisational and environmental factors that shape crisis response capacity in

organisational systems?; 2) How to self-assess crisis preparedness and response capacity of an organisation?; 3) What can an organisation do to enhance its resilience in relation to crisis preparedness and response capacity?

With this framework, we aim to bridge and advance crisis management and resilience research by applying the multilevel and continuous approach to comprehensively describe and analyse key factors that shape organisational crisis preparedness and responses, and develop learning mechanisms to enhance organisational resilience. Furthermore, we believe that our framework guides how an organisation self-assesses its crisis preparedness and response capacity, and learns from the assessment results to strengthen its capabilities.

We have organised the article as follows. First, an overview of existing literatures on crisis management and resilience is presented, particularly those that recognise multilevel factors that shape crisis preparedness and responses in organisational systems. This review sets the tone for describing the role of learning from rare events in strengthening organisational capabilities. Following that, we introduce the multilevel framework with which an organisation can self-assess its crisis preparedness and responses, and as a next step learn to improve enhance. Further, we validate the framework with a case study of an organisation operating within the security services sector. Next, we discuss the advantages of applying multilevel and continuous approaches in the framework. In particular, we highlight the benefits of reviewing and analysing individual, organisational and environmental factors that shape crisis preparedness and response capacity, as well as the multilevel learning mechanisms to enhance resilience in organisational systems. The conclusion summarises theoretical and empirical contributions of the paper.

4.2. Multilevel Factors of Crisis Management and Resilience

Crises can result from both unexpected triggering events or systematic organisational weakening (Williams et al., 2017). Crisis management and resilience efforts are essentially intertwined and depended on each other. The recent efforts to integrate the research on crisis management and resilience resulted in more inclusive definitions (see Williams et al., 2017). An organisation cannot be resilient without effective crisis management, which involves weak signal detection to minimize potential risk before a triggering event, swift responses and recovery, as well as learning to increase preparedness for future adversities (Christine M. Pearson & Mitroff, 1993). Similarly to crisis management, resilience is a dynamic process, which arises at multiple levels and develops over time (Lengnick-Hall & Beck, 2005; Sutcliffe & Vogus, 2003). From the developmental perspective, resilience is an organisational feature that improves when organisational capabilities are strengthened (Williams et al., 2017), and that creates enabling conditions for positive adjustments (Sutcliffe & Vogus, 2003). Resilience analysis should also trace dynamic interactions between organisation and its environment to recognise and absorb environmental changes (Walker, Holling, Carpenter & Kinzig, 2004). To address these complexities, in the following lines, we present an overview of literature findings on factors at individual, organisational and environmental levels that shape crisis preparedness and responses, as well as the learning processes that strengthen organisational resilience.

4.2.1. The individual level

Psychological and sociological perspectives are mostly applied in investigating individual-level factors that influence crisis responses and resilience. Most researchers in this area focused their analysis on human behaviour, cognition and social relations in response to crisis. Also, they have looked for sources of crises in behaviours, cognitive limitations, and social incompetence. According to Lengnick-Hall et al. (2011), organisational resilience is

embedded in a set of employees' knowledge, skills, and abilities, therefore, strategic human resource management is crucial for developing capacity for organisational resilience. Individuals can develop cognitive, behavioural, emotional, and relational capabilities to better anticipate and respond to adverse events (Christine M Pearson & Clair, 1998; Williams et al., 2017). Cognitive capabilities include ability to detect signals, understand, analyse and develop responses. When crisis occurs, individuals try to make sense under uncertain conditions and accordingly respond to adversity (Maitlis & Sonenshein, 2010). In this light, researchers have highlighted the importance of creative thinking, flexibility and mindfulness in formulating responses (Lengnick-Hall & Beck, 2005; Lindberg & Rantatalo, 2015; Sutcliffe, Vogus & Dane, 2016). Furthermore, resilience capacity of an individual is strengthened by prior knowledge and experience (Bonanno, Brewin, Kaniasty & Greca, 2010; Williams & Shepherd, 2016), which can facilitate faster and more accurate responses. Behavioural capabilities comprise action that is a result of cognitive reply, thus, the effectiveness of crisis responses depends to a large extent on cognitive capabilities. As Perrow (2011) has noted, the individual's behaviour is additionally constrained by organisational design and culture. Further, crises are emotional events with considerable amount of stress. Emotional capabilities provide individuals with the psychological assets that mitigate stress and allow the one to stand firm in the uncertain environment (Baron, Franklin & Hmieleski, 2016). In fact, emotions play also a key role in the crisis sense-making processes (Maitlis & Sonenshein, 2010; Weick, Sutcliffe & Obstfeld, 2005). Positive emotions boost individual's creativity (Amabile, Barsade, Mueller & Staw, 2005). Therefore, individuals are likely to enhance their resilience by growing emotional endowments (Williams et al., 2017). From another point of view, individual relations (both formal and informal) play an important role in shaping immediate actions and mobilising internal and external resources to respond to adversity (Lengnick-Hall et al., 2011). The implication is that reliable organisational performance is thoroughly social, therefore, social

competence and interpersonal skills are a necessity in high reliability organisations (Lindberg & Rantatalo, 2015; Weick & Roberts, 1993). As Williams et al. (2017, p. 745) pointed out, “relational capabilities provide a context in which cognitive, behavioral, and emotional capabilities can be activated.”

4.2.2. The organisational level

Recent studies on organisational-level factors pay attention to collective cognitive, behavioural, emotional, relational and sociomaterial capabilities (Lengnick-Hall & Beck, 2005; Orlikowski, 2007; Williams et al., 2017). In relation to these capabilities, researchers have also investigated the role of organisational culture, structure (Bundy et al., 2017), and technology (Christine M Pearson & Clair, 1998) in shaping work environment. This internal organisational context is important in explaining organisational responses to crisis. As Lengnick-Hall et al. (2011) have argued, organisational resilience results from organisational capabilities, routines, practices, and processes. In line with that, Heinemann and Hatfield (2017) introduced a framework for resilience analysis in which the “establishing the context” aims to understand internal governance arrangements, operational procedures as well as human interactions within an organisation. Important to highlight in this aspect is the notion of organisational culture as collective mind, an outcome of which Weick and Roberts (1993, p. 23) refer to “a well-developed organisation mind, capable of reliable performance” which is “thoroughly social...[and] built of ongoing interrelating and dense interrelations.” It is based on the argument that crisis requires collective responses, which are the most effective when organised through the collective mindfulness (Weick et al., 1999), i.e. when the shared meanings, respectful interactions, improvisation (Weick, 1993), flexibility (Bigley & Roberts, 2001), and joint responsibility are present (Lengnick-Hall et al., 2011). In organisations, trustful relationships, i.e. social capital, are the fundamental for collective sensemaking, taking up a

collaborative action and facilitating organisational resources flow (Gillespie & Dietz, 2009; Krackhardt & Stern, 1988; Weick & Roberts, 1993). Thus, it is important to build successful relational systems to enhance organisational resilience (Kahn et al., 2013). In fact, in crisis situations, informal social relations build unconventional bridges cross organisation to supplement unavailable formal connections. In this light, strategic human resource management was found crucial to generate resilience outcomes (Lengnick-Hall et al., 2011). Williams et al. (2017) suggest that organisations should cultivate emotional capital to enhance resilience, and as one of the strategies they recommend openness to express and discuss emotions. Furthermore, organisations are sociotechnical systems and sociomaterial assemblages¹⁴ shape organisational behaviour (Orlikowski, 2007). The complex dynamic interaction between people and technology may resolve in unexpected adversity to which an organisation has to respond (Amir & Kant, 2018; Cecez-Kecmanovic, Galliers, Henfridsson, Newell & Vidgen, 2014). Therefore, preparing for and coping with crisis must involve tangible and intangible organisational resources (Christine M Pearson & Clair, 1998). In this regards, researchers (e.g. McManus, 2008) have underlined the importance of physical (buildings and services) and human components (communication, coordination, management, planning, etc.) in enhancing resilience. Therefore, the sociomaterial interactions are important factors that affect organisational resilience. In sum, organisations should develop and grow cognitive, behavioural, emotional, relational and sociomaterial capabilities to improve resilience. The improvement should be a continuous process of adjusting and readjusting to the dynamic

¹⁴ The term “sociomaterial” refers to the entanglements of the social, i.e. beliefs, trust, personal ties, norms, values, etc. and the material, i.e. computers, buildings, communication devices, etc. The configuration of these entities constitute organizational life and shapes how organization performs.

context changes (Kovoor-Misra, 1995; Christine M Pearson & Clair, 1998; Williams et al., 2017).

4.2.3. The environmental level

Heinimann and Hatfield (2017) have argued that organisations are non-deterministic systems whose resilience must be viewed beyond local system boundaries. Due to this interactive and dynamic nature of resilience, researchers took numerous attempts to understand organisation's environment. Most of the research at this level focused on relationships with stakeholders (James, Wooten & Dushek, 2011), institutionalized practices and industry regulations (Kant & Tasic, 2018). To achieve goals, organisations are bounded with their environment (Kovoor-Misra, 1995) through different types of interdependencies (authority and regulations, exchange of information, products, financial resources, technologies and services, etc.). In this regard, stakeholder management was the primary research area to discover how relations with a stakeholders network (governments, industry bodies, media, local communities) influence organisation's crisis operations. On one hand, "organizations are pressured by external stakeholders and public opinion to act more safely and responsibly" (Hällgren et al., 2018, p. 131). On the other hand, relationships with stakeholders help in facilitating crisis responses through resource flow and mitigating crisis consequences (Lengnick-Hall et al., 2011; Tasic & Amir, 2016). Therefore, it is important that organisations involve stakeholders in crisis preparations, i.e. integrate with stakeholders, manage their expectations, and maintain organisation's legitimacy (Pfarrer, Decelles, Smith & Taylor, 2008). In this way, stakeholders' judgment of crisis should be a key consideration, and thus managing effective stakeholder communication is essential. Communication is important to maintain or rebuild organisation's legitimacy, and in this regard the media play a central role in how crisis is interpreted by stakeholders. In similar directions, stakeholders' judgement can be influenced by aligning

organisation's response strategy with stakeholders' perception (Bundy & Pfarrer, 2015). However, the prior positive organisational performance under crisis may create stakeholders expectations for future positive performance, and thus additional pressures on organisation (Bundy et al., 2017). Furthermore, Clair and Waddock (2007) highlighted that listening to the concerns of stakeholders allows signals detection and potential crises prevention. In sum, stimulating stakeholder relationships is a key factor to enhance organisational resilience.

4.2.4. Learning from crises

Research on crisis management and resilience generally stems from the premise that organisation can learn lessons to improve capacity to prevent and respond to crises. Because resilience is a collaborative problem, which requires continuous learning and adaptation at multiple levels (Heinimann & Hatfield, 2017), individuals are more resilient to a crisis if they have experienced similar crisis in the past as part of groups (Bonanno et al., 2010). This entails that organisational performance improves with leveraging on individuals' experience, which allows organisation to introduce necessary modifications (Madsen & Desai, 2010). However, people tend to neglect errors they perceive as minor, resulting in undetected weak signals (Weick et al., 1999) and decreased learning (March, Sproull & Tamuz, 1991). Organisational culture may create a climate that will encourage attention to errors and willingness to report them. These efforts may allow "people to learn from errors individually and collectively and to make adjustments" (Hällgren et al., 2018, p. 123). Researchers investigated organisational learning in relation to single and double loop learning processes (Argyris & Schon, 1996; Metallinou, 2017). While single-loop learning focuses on actions to achieve a pre-set goal with existing means (e.g. emergency response procedures, human and material resources), in double-loop learning involves questioning the underlying assumptions of the goal, what may result in implementing new procedures (e.g. new emergency response standards) (Metallinou,

2017), strategies, and technology. Organisations are quite good at single loop learning; however, double loop learning is still rare (Argyris & Schon, 1996). On one hand, organisations constantly evolve and learning from an experience is not static, rather it weakens over time and depends on the context (Haunschild, Polidoro Jr & Chandler, 2015; Madsen & Desai, 2010). On the other, opportunities to learn from direct experience with extreme events are very limited due to their rare occurrence (Hällgren et al., 2018). Therefore, crisis preparation must be an ongoing process that entails identification of vulnerabilities and development of capabilities, testing of the capability, and continuous process of learning (Kovoor-Misra, 1995). In this light, preparedness exercises have been found essential to practice and test response activities and roles, and linkages with stakeholders (Christine M Pearson & Clair, 1998). Through exercises, an organisation builds experience and expands organisational perspectives on crisis. This may lead to learning, as well as adjusting and changing current status quo, and thereby increasing the resilience capacity to respond to actual crisis in the future.

4.3. Framework

Drawing on the evidence in existing literatures, we introduce a conceptual framework to explain the multilevel elements that allow an organisation to self-assess its crisis preparedness and response capacity in order to enhance organisational resilience. In this approach, our multilevel framework comprises four phases: 1) reviewing and monitoring context, 2) testing preparedness, 3) analysing and assessing responses, and 4) strengthening capabilities (Figure 12). In the following lines we will describe the phases and their elements at individual, organisational and environmental levels.

Figure 12. Multilevel Framework for Enhancing Organisational Resilience.

4.3.1. Reviewing and monitoring context

As highlighted in the literature review, organisational resilience and crisis management should be addressed at multiple levels. We distinguish three multilevel elements that should be considered as part of reviewing and monitoring context: *individual resources*, *organisational resources*, and *the environment*. While, individual and organisational resources constitute internal organisational context, the organisation's environment is the external context. In this regard, internal crises are related to organisational weakening, and external crises result from changes in environment. Both rarely appear without warning signals, and both can be prevented or mitigated by good understanding and monitoring of internal and external context of the organisation. Detecting the signals is not easy due to the constantly increasing amount of processed information and interdependencies in organisational systems; however, the multilevel analysis of resources can give a more comprehensive overview on the factors that condition organisational performance. Thus, it is essential to recognise the importance of each of the elements and review them separately to reveal new insights that affect how actually the work is done and which factors condition the performance. The review and monitoring phase

can be conducted both with quantitative and qualitative methods, depending on the organisational context and available resources.

First, it is important for an organisation to have a good understanding of its own capabilities (Williams et al., 2017); therefore the review of the individual and organisational resources begins the path to enhancing organisational resilience. In line with the literature findings, *individual resources review* focuses on examining employees' cognitive, behavioural, emotional and social capabilities. The individual-level review could answer some of the following questions: 1) Which knowledge and skills do employees need to support organisation's operations and which they actually have? 2) Which coping styles do employees have? 3) What is employees' psychometric resilience level? 4) How mindful are employees? 5) Do employees have well-developed social competences? 6) Is there value congruence between individual and organisation?

Next, *organisational resources review* explores collective cognitive, behavioural, emotional, relational and sociomaterial capacities of an organisation. The organisational-level review could address, among others, the following questions: 1) What kind of crises has an organisation responded to in the past? 2) What crisis management and contingency plans do the organisation have? 3) Which capacity building trainings, simulations have been organised in the past? 4) Who are the most important formal and informal leaders in the organisation? 5) What is organisation's culture like (approach to safety, reporting errors, mindfulness)? 6) What sociomaterial resources and practices does the organisation possess?

The *environment review* is about analysing and understanding organisation's external context, i.e. the environment. It concerns relations with stakeholders (governments, industry bodies, media, local communities, suppliers, financial markets, etc.), institutionalized practices and industry regulations. The issues to be reviewed may include: 1) Which of the stakeholders are

important while confronting adversities (i.e. which affect organisation's crisis management and which are affected by it)? 2) Does the organisation have integrated relations with stakeholders? 3) Are there any environmental pressures and changes that have to be addressed (e.g. regulations changes, economic development shifts, trade barriers, energy resource limitations, technology changes, and knowledge transformations)? And lastly, the phase of multilevel review is aimed at revealing organisation's vulnerabilities, that is, the review should answer "what can go wrong?" (Kaplan & Garrick, 1981) and why it can go wrong. Answering these questions will allow an organisation to identify the areas that require improvement.

4.3.2. Testing preparedness

Once multilevel review reveals weaknesses that may affect crisis responses, it seems natural that the organisation should test its crisis preparedness in practice. Testing can be conducted through exposing members of the organisation to a simulated crisis. The exercise scenario is developed on the basis of multilevel review inputs, which indicate areas that should be tested. While defining the simulation scenario, some of the questions that should be asked include: 1) Does the scenario address testing the detected weakness(es)? 2) Is the developed scenario possible to happen? 3) Does the exercise design provide enough inputs for analysis and assessment? The testing phase aims not only to check organisational preparedness but also to enrich employees' experience with facing crisis, thus enhance their crisis response capacity for a similar event in the future. Learning from this experience should take place at multiple levels, as described in details in the last phase of the framework.

4.3.3. Analysing and assessing responses

After testing the preparedness, the crisis responses should be analysed and assessed. Depending on the scenario and exercise method the assessment can be qualitative, quantitative or mixed.

In this phase, the analysis should be conducted at multiple levels, in line with the review levels (individual, organisational, environmental). The analysis concentrates on identifying both strengths and weaknesses of the responses. The strengths will indicate the directions that should be recognised and cultivated by an organisation in the future, e.g. safety culture, swift detection of weak signals, strong emotional and instrumental support, etc. The weak points will point out the areas that have to be improved to increase organisational preparedness (ignorance of weak signals, gaps in the crisis procedures, lack of resources, skills, knowledge, social incompetence, weak communication with stakeholders). At this point of response assessment, the organisation should be able to answer such questions as: 1) How well did employees respond to the simulated crisis? 2) Which of the skills were useful? 3) Did current organisational structure and procedures work efficient? 4) Were organisational values reflected in the responses? 5) Which sociomaterial resources and practices were crucial to respond? 6) How well were managed relations with stakeholders?

4.3.4. Strengthening capabilities

Importantly, through practising responses and drawing the lessons, an organisation may expand cognitive, behavioural, emotional, relational, and sociomaterial perspectives, thereby strengthen organisational capabilities to cope with actual crisis. The conclusions from the response analysis and assessment are necessary to learn the lessons. However, it is important to keep the organisation up-to-date with state-of-the-art theory and practice, and also incorporate them in the lessons. Three types of lessons should be learnt in parallel at multiple levels: organisational adjustment or transformation, environment stimulation, and crisis redefinition. *Organisational adjustment or transformation* concerns the internal organisational context, which is comprised by two levels, i.e. individual and organisational resources. The lessons affect changes of a different degree, i.e. adjustment (single loop learning) or

transformation (double loop learning). *Environment stimulation* comprises the lessons that send a feedback to the environment to motivate changes in stakeholder relations, institutionalized practices and industry regulations, which in turn will facilitate better organisation's crisis preparedness and responses in the future. In addition, the response assessment results may reveal new insights that will require refocusing to new weaknesses and potential *crisis redefinition*, resulting in new exercise development as well as analysis and assessment as the following phase.

Following Kovoov-Misra (1995), crisis preparedness must be an ongoing process as both organisations and their environment constantly change and evolve. These dynamic processes, including enhancing resilience, can be embraced and well-addressed only with the continuous approach to application of the framework (see Figure 13). Therefore, the cyclic way of employing the framework allows the organisation to verify whether the lessons were actually learnt, and to maintain situational awareness in case there are any new signals of weakening and environmental pressures that should be examined.

Figure 13. Continuous approach to embrace dynamics of organisational processes.

4.4. Case Study of Simulated Crises

4.4.1. Validation approach

The biggest challenge in resilience studies is how to test organisational capacities when crisis is not occurring. A common approach is to study resilience after the crisis (e.g. Aldrich & Meyer, 2015) to examine a correlation of one social variable to resilience. While this approach is useful to understand resilience factors, it is not meant to yield preventive and prescriptive outputs for the organisation. Another possible means to assess organisational resilience is a simulation of crisis. This is how we validate the proposed framework via a case study analysis, and thus, present in practice how an organisation can use the framework to enhance its resilience. We conducted an empirical research with a research and training outfit, which operates within the security services sector in Southeast Asia. Functioning as an operational centre, the outfit has approximately 30 employees. We collected data for over a 3-month period through observation, interviews, and simulation exercise questionnaires. We divided the data collection into two phases. In the first phase, the multilevel review was conducted through observation, interviews, questionnaires and document studies. The first author spent over a month observing and analysing the organisational context. Next, we conducted four open-ended interviews with senior staff on work culture, safety procedures and relations with stakeholders and industry. Further, we sent questionnaires to get quantitative overview of the individual and organisational resources, and received 26 completed forms. In the second phase, we used simulation questionnaires to test the organisation's responses towards two simulated crises—a terrorist attack and secret information loss. The questionnaires were designed in Adobe LiveCycle Designer and sent electronically with a time distance of 3 weeks. The included questions had both open- and closed-ended type and were related to individual level (e.g. severity perception, response steps, skills, and coping behaviours), and organisational

level items (e.g. organisation's response role, sociomaterial resources, organisation's preparedness). The environment level was constructed from qualitative answers that related to external organisational context. In total, we received 46 complete questionnaires (25 for the terrorist attack scenario, 21 for the data loss scenario). The analysis of qualitative data related to individual, organisational, and environment levels was handled in NVivo 11 software. Lastly, to assess response correctness, we analysed formal documents, such as crisis response protocols.

4.4.2. Validation results

Multilevel review and monitoring of context

In line with the framework, we first reviewed the internal and external organisational context to identify organisational vulnerabilities. First, the one-month observation was conducted to better meet the organisational context. Next, in consultation with the senior managers, we made profiles of desired knowledge and skills for each of employees' roles (see examples in Table 9). Further, through questionnaires, we examined employees' coping styles (16 items selected from Brief Cope scale by Carver (1997)), psychometric resilience (10-item scale by Campbell - Sills and Stein (2007), mindfulness (6 items selected from the work of Weick and Sutcliffe (2011)), task interdependence (2 items selected from the scale of Pearce and Gregersen (1991)), individual-organisation value congruence (2-item scale by Posner and Schmidt (1993)), and social interactions (social network analysis metrics; see networks models in Appendix 4, Figure A-D). The average employee results and social interaction measures are described in Table 10 and Table 11.

Table 9. Examples of necessary knowledge and skills.

Role	Knowledge	Skills
Role 1	<ul style="list-style-type: none"> • Psychological support • Critical Incident Stress Management (CISM) • Self- and others-care techniques • Crisis negotiation techniques • Counselling techniques • Grief management • First aid • Operational knowledge 	<ul style="list-style-type: none"> • Providing psychological support • Managing crisis stress and negotiations • Decision-making • Situation awareness • Communication skills • Active listening • Staying calm in stressful situations (self-mastery) • Flexibility • Prioritizing • Interpersonal skills
Role 2	<ul style="list-style-type: none"> • Research methods • Crisis management methods • Psychological knowledge • First Aid • Operational knowledge (standards and procedures) 	<ul style="list-style-type: none"> • Case study analysis • IT and data mining skills • Analytical skills • Critical thinking • Writing skills • Problem-solving • Objectivity • Creativity and resourcefulness • Paying attention to details • Active listening • Interpersonal skills • Communication skills • Responding quickly to operational needs • Staying calm in stressful situations (self-mastery)
Role 3	<ul style="list-style-type: none"> • Operational knowledge (standards and procedures) • First Aid 	<ul style="list-style-type: none"> • Logical thinking • Communication skills • Prioritizing • Problem-solving • Active listening • Responding quickly to operational needs • Staying calm in stressful situations (self-mastery)

Table 10. The average employee scores (organisational level).

Metric	Average individual score	Examples of items
Coping styles	<i>Scale range: 0-3*</i>	
Active coping ($\alpha=.81$)	2.5 [^]	"I take an action to try to make the situation better."
Planning ($\alpha=.48$)	2.5 [^]	"I try to come up with a strategy what to do."
Positive framing ($\alpha=.73$)	1.9	"I look for something good in what is happening."
Acceptance ($\alpha=.84$)	2.3 [^]	"I accept the reality of the fact that it happened."
Humour ($\alpha=.97$)	1.7	"I make fun of the situation."
Religion ($\alpha=.94$)	1.5	"I try to find comfort in my religion"
Emotional support ($\alpha=.94$)	2.1 [^]	"I try to get emotional support from others."
Instrumental support ($\alpha=.98$)	2.4 [^]	"I get help and advice from other people."
	<i>Scale range 0-4**</i>	
Psychometric resilience ($\alpha=.84$)	2.8	"I am able to adapt when changes occur."
Mindfulness		
Individual ($\alpha=.76$)	2.6	"I'm familiar with operations beyond my own job."
Collective ($\alpha=.75$)	2.2	"Me and my colleagues have agreement on what we don't want to go wrong."
Task interdependence ($\alpha=.53$)	2.8	"I frequently must coordinate my efforts with others."
Value Congruence ($\alpha=.50$)	2.5	"My personal values are generally compatible with the values of my organization."

* Indicate what you usually do: 0 - not at all, 1 - a little bit, 2- a medium amount, 3 - a lot

** How much do you agree: 0 - not at all, 1 - rarely, 2 - sometimes, 3 - often, 4 - all the time

[^] If value ≥ 2 , the coping style is recognised

Table 11. Social interaction measures.

Network	Degree centralisation ¹⁵	Transitivity ¹⁶	Question
Acquaintance (work talks)	0.15	0.40	“With whom do you like to discuss your daily work?”
Friendship (private talks)	0.19	0.47	“With whom do you talk about your private affairs during your daily chats?”
Problem- solving	0.19	0.54	“Whom do you ask for help when you encounter a work-related problem, for which you couldn’t find a solution yourself?”
Motivation	0.22	0.50	“Who has been an important motivator, bringing in a positive spirit to advance your work?”

Next, with interviews and observation, we reviewed organisational culture and structure, sociomaterial resources and practices, and relations with environment. As Hällgren et al. (2018) have suggested, an organisation operates in the emergency context where each failure brings severe consequences; therefore, safety is the operational priority of the organisation. This is reflected in the strong safety culture as noted by Pidgeon and O’Leary (2000), which cultivates employees empowerment, sensitivity to generalisations, care and trust, as well as continuous commitment to safety and organisational learning. This was additionally confirmed with high average scores in psychometric resilience, respective coping styles (active coping, planning, acceptance, emotional and instrumental support) as well as rich and well-balanced trustful interactions. In the interviews with senior staff, we discussed existing crisis management and contingency plans, types of crises that occurred in the past, trainings that were conducted and sociomaterial resources that organisation possesses. Additionally, we traced the sociomaterial practice cues during the observation period. Due to the important mission,

¹⁵ Network degree centralisation is the sum of differences in centrality between the most central node in a network and all other nodes, divided by the theoretical maximum.

¹⁶ Transitivity measures the probability that the adjacent vertices of a vertex are connected.

operations of the organisation affect many stakeholders, among which are other security services organisations as well as media, community, and community leaders.

Test of preparedness

The multilevel review of resources revealed organisational vulnerability to two crisis settings—a *terrorist attack* and *loss of secret information*, which would have a severe impact on the organisation's operations and its stakeholders, if they occur. At the time the research was conducted, both of the crises have not been tested in practise yet, and there was no directly related training. In agreement with the senior management, we proceeded to test organisational preparedness towards those two scenarios. A terrorist attack is an external crisis, which results from a sudden threat from organisational environment. Over last decades, the number of terror-related threats has risen dramatically around the world and in Southeast Asia (Abuza, 2003; Ramakrishna & Tan, 2003). In case a terrorist attack happens, the organisation is likely to be an active part in responding to the crisis. The “secret” data loss is an internal crisis that results from weakening the organisational culture and procedures (so called ‘insider threat’). Nowadays, information technology facilitates the everyday work practice, including storing and exchanging information of different importance. Therefore, the security of information and information technology should be an organisation's priority. Although the data loss has never happened before in the organisation, there was a need to raise awareness regarding information security. To confirm our indications, we consulted the detected vulnerabilities with the senior staff, and who also crosschecked the developed exercises scenarios to ensure their reality. We also verified the scenario reality by asking respondents if they perceive the described scenario possible to happen. Finally, we confirmed that the exercise design provides enough inputs for analysis and assessment. The details on simulation scenarios as well as general response areas are described in Table 12.

Table 12. Key crisis simulation characteristics and response areas

Scenario	Key Simulation Scenario Elements	Examples of Response Activities
Terrorist attack	<i>Main scenario:</i>	<i>Role 1:</i>
	<ul style="list-style-type: none"> • 3 active shooters dressed in police officer uniforms and masks • Weekday • In central area • Civilians dead and wounded • Officers injured • Chaos on the streets 	<ul style="list-style-type: none"> • Coordinate with community leaders • The ensure safety measures are undertaken for operations • Provide PFA to community • Update crisis management cell, which coordinates the teams
	<i>Inject:</i>	<i>Role 2:</i>
	<ul style="list-style-type: none"> • A colleague wants to head down for the activation even though he/she doesn't feel well (weak signals): 	<ul style="list-style-type: none"> • Report to operations centre • Analyse the indicated area of research / field study • Ensure safety measures are undertaken for operations • Provide research inputs
		<i>Role 3:</i>
		<ul style="list-style-type: none"> • Coordinate with relevant emergency response team on needed resources • Keep track and account for manpower and resources activated • Update the crisis management cell on resource management issues
“Secret” data loss	<i>Main scenario:</i>	<i>Role 1 and 2:</i>
	<ul style="list-style-type: none"> • Colleague from the branch notices that he/she lost confidential data classified as “Secret” • The data was stored at the laptop 	<ul style="list-style-type: none"> • Report loss to the senior manager • Help in gathering information • Make a police report • Cooperate in any investigation forms
	<i>Inject:</i>	<i>Role 3:</i>
	<ul style="list-style-type: none"> • Unusual behaviour of the colleague who lost the data (weak signals) 	<ul style="list-style-type: none"> • Account for logistical compromises within organisation • Cooperate in any investigation forms

Multilevel analysis and assessment

We conducted both qualitative and quantitative multilevel assessment of the exercised crisis responses to reveal insights on individual, organisational and environmental factors that influence the organisation's crisis responses. The qualitative data were abstracted into levels (individual, organisation and environment) and categories (see more details in Appendix 5, Table A and B). In line with the framework, at the individual-level we categorised employees' cognitive, behavioural, emotional and social capabilities, and at the organisational-level we coded collective cognitive, behavioural, emotional, relational, and sociomaterial capabilities. The environment-level cues described the relations with stakeholders, in particular information exchange and collaboration as well as impact of the crises.

In the quantitative part of the individual level, we focused our analysis on individuals' crisis severity perception, response correctness, used types of skills, and weak signal detection; at the organisational level, we examined the importance of organisation's sociomaterial capabilities in two scenarios. The employees perceived both of the crises as severe; however, the terrorist attack was seen as more severe ("extremely severe") than the "secret" data loss ("very severe"). The quantitative assessment was conducted on the basis of formal protocols of crisis responses that were received from the organisation. We calculated the scores of response correctness by counting the number of correct response steps and normalising them by the total number of expected steps. We crosschecked the assessment methods with senior managers. In case of the data loss scenario the average correctness of employee accounted for 80%, and the terror attack 85%. Next, we analysed individuals skills used in crisis responses. We categorised them into three groups: transferable, knowledge-based, and self-management (Figure 14). There was no surprise that transferrable skills in both scenarios accounted for 51% of total used skills. Interestingly, while in case of the terrorist attack knowledge-based skills were meaningful

(36%), in the data loss scenario they were less important (11%) and exchanged with self-management skills (28%). We concluded that those differences are related to the different crisis types (internal and external).

Examples of identified skills:

<i>Transferable:</i>	<i>Knowledge-based:</i>	<i>Self-management:</i>
<ul style="list-style-type: none"> • Critical thinking • Communication • Situational awareness • Problem solving • Analytical thinking • Adaptability/flexibility • Team work • Creativity 	<ul style="list-style-type: none"> • Crisis decision making • Crisis management • Operational knowledge (plans, procedures) • Psychological first aid • Memory retrieval techniques • Research methods 	<ul style="list-style-type: none"> • Emotional regulation • Calmness • Personal management • Clarity of mind • Empathy • Conscientiousness • Meticulousness

Figure 14. Skills used in crisis responses.

Further, we examined the weak signals detection. We counted the weak signals as correctly detected if an employee considered reporting them to superior as “considerably” or “very likely” (3 or 4 in the scale 0-4). In the data loss scenario, weak signals were detected correctly by 77% of employees, and in the terror attack scenario by 88% of employees (Figure 15). Similarly to the skills types differences, we attributed it to the different crisis types. In relation

to the coping styles, more than half of employees would use emotional and instrumental support in case of terrorist attack (52% and 56% respectively), while in case of the “Secret” data loss 76% and 62% of employees (Figure 15). The in both scenarios, emotional coping had more informal character, meaning that employees looked to receive emotional support from a close colleague. On the other hand, the instrumental coping had both formal and informal character, i.e. employees searched for an advice both from fellow colleagues and a supervisor.

Figure 15. Weak signals detection and used coping styles

In the following step, we analysed the reported importance of sociomaterial resources in the two scenarios (Table 13). On average most of the investigated sociomaterial resources were more important in case of the terrorist attack than “secret” data loss, in particular alert systems,

phones, telecommunication network, cooperation with emergency response team, coordination with top management, resource allocation, crisis and risk management plans.

Table 13. Average importance of organisation's sociomaterial capabilities in crisis responses

Sociomaterial Resource	Terrorist attack	"Secret" data loss
Importance Scale: 0-4		
<i>Buildings and equipment</i>	3.01*	2.39*
Offices	2.16	1.71
Security systems	3.20	3.05
Alert systems	3.48*	2.62*
Vehicles	3.00	1.14
IT software	3.16	3.33
IT hardware	3.12	3.05
Phones	3.76*	2.62*
Other equipment	2.20	1.62
<i>Services</i>	3.31*	2.19*
Fuel supply	2.76*	1.05*
Telecom network	3.64*	2.62*
IT network	3.52	2.90
<i>Information</i>	3.23	2.98
Acquisition	3.36	2.95
Transfer	3.28	2.81
Protection	3.04	3.19
<i>Cooperation relationship</i>	3.50*	3.15*
Top management	3.68	3.62
Senior Leaders	3.56	3.43
Other employees	3.32	3.19
Emergency response team	3.44*	2.38*
<i>Communication relationship</i>	3.55	3.35
Top management	3.84	3.67
Senior Leaders	3.60	3.57
Other employees	3.32	3.43
Emergency response team	3.44	2.71
<i>Coordination relationship</i>	3.58*	3.24*
Top management	3.84*	3.57*
Senior Leaders	3.68	3.48
Other employees	3.16	3.29
Emergency response team	3.64	2.62
<i>Management and leadership</i>	3.49*	3.10*
Crisis management structure	3.52	3.14
Situation assessment	3.72	3.33
Decision-making	3.84	3.76

Team management	3.68	3.48
Resource allocation	3.40*	2.57*
Staff welfare	2.76	2.29
<i>Planning and preparedness</i>	3.62*	3.05*
Crisis management plan	3.80*	3.29*
Continuity plan	3.44	2.90
Risk management plan	3.60*	3.24*
Crisis trainings and exercises	3.64	2.76

* Largest differences between scenarios

Importance scale: 0- not at all, 1- slightly, 2 – moderately,
3 – considerably, 4 – extremely

4.5. Findings and Discussion

Based on the multilevel analysis and assessment of crisis responses, and findings of state-of-the-art review, we identified the multilevel lessons that should be learnt and implemented to strengthen organisational capabilities, and thus enhance organisational resilience (Table 14 below).

Table 14. Examples of lessons learnt at multiple levels.

Learning type	Identified Lesson	Potential Implementation Activities
<i>Individual-level</i>		
<i>Adjustment</i> (single loop learning)	<p>Each crisis has different response requirements that can be accommodated with strong individual capabilities of a diverse range:</p> <ol style="list-style-type: none"> 1. Strengthen cognitive capabilities of employees by enriching their operational knowledge and sense-making strategies. 2. Strengthen behavioural capabilities of employees by rehearsing the practical application of crisis response procedures. 3. Strengthen emotional capabilities of employees by building coping strategies. 	<ul style="list-style-type: none"> • Information security training and certification • Compulsory and repeated integrity tests • Hands-on exercises customised to all response roles, and followed by action review and lessons learnt

<i>Transformation</i> (double loop learning)	<ol style="list-style-type: none"> 1. Social competences should become important part of recruitment processes. 2. Build familiarity with operations beyond own job. 	<ul style="list-style-type: none"> • Evaluation of social competences during the interview • Add cross-functional individual assignments
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Organisational-level

<i>Adjustment</i> (single loop learning)	<p>Each crisis has different features that require strong organisational capabilities to respond to them:</p> <ol style="list-style-type: none"> 1. Strengthen organisational culture values regarding information storage and sensitivity 2. Collective emotional and instrumental coping play an important role in crisis responses thus should be promoted. 3. Collective cognitive, behavioural and relational capabilities can be stimulated by both formal and informal integration mechanisms. 4. Sociomaterial capabilities can be strengthened by better use of current technology. 	<ul style="list-style-type: none"> • Cyclically update organisational culture codes of conduct • Increase number of teamwork trainings • Increase number of interdependent tasks (across-branch task forces) • Group evaluations and incentives • Enhance monitoring system • Enhance data storage procedures • Enhance strategies of communicating standard operation procedures to staff • Adapt spatial office arrangements to increase social interactions
<i>Transformation</i> (double loop learning)	<ol style="list-style-type: none"> 1. Due to the progressive technology changes, there is a need to create new response procedures in case of confidential data loss. 2. New technology solutions can help in mitigating crisis, as well as facilitating realistic training exercises. 	<ul style="list-style-type: none"> • Introduce new SOPs for confidential data loss • Introduce Augmented Reality (AR) trainings • Introduce GPS tracking technology in devices that store confidential information
<i>Crisis redefinition</i> (double loop learning)	Emerging crisis scenario for future testing: cyber attack scenario	Exercise testing preparedness for a cyber attack

<i>Environmental-level</i>		
<i>Environment stimulation</i> (single and double loop learning)	Each crisis response requires strong and trustful relations with diverse stakeholders: <ol style="list-style-type: none"> 1. Coordinated crisis responses requires unifying the communication protocols across all stakeholders. 2. Coordinated crisis responses to requires more exercises with stakeholders. 3. Build trust and engagement among stakeholders - campaign to initiate new collaborations. 4. New technology applications can enable new information exchange channels. 	<ul style="list-style-type: none"> • Enhancing inter-stakeholder crisis communication strategy • Unifying public statement booklets and ready-to-go messages • Full simulation exercise with all stakeholders • Introduce new collaboration projects • Introducing facial recognition eyeglasses in crisis operations

Resilience is one of the most desired capacities in which an organisation uses its resources, along with environment relations, to maintain and adjust to an acceptable level of preparedness and ability to respond and recover from unforeseen crisis. As a dynamic process, resilience can be enhanced over time by adjusting and strengthening organisational capabilities. This can be achieved by maintaining internal and external organisational awareness, building experience, learning, and introducing modifications. Even though building and enhancing organisational resilience requires maintaining and adjustment crisis management efforts at multiple levels most of the research tried to address it only from a single level perspective (e.g. Lengnick-Hall et al., 2011; Sutcliffe & Vogus, 2003; Van Der Vegt et al., 2015). In response to this challenge, we advanced crisis management and resilience research by introducing the multilevel framework for enhancing resilience. The framework comprises four phases: 1) reviewing and monitoring context, 2) testing preparedness, 3) analysing and assessing responses, and 4) strengthening capabilities, that are decomposed at individual, organisational, and environmental levels. Mounting multilevel results leads to lessons that should be learnt at

multiple levels to comprehensively increase organisational capabilities to cope with crises, and thus, enhance organisational resilience. We validated the framework and showcased its practicality with the case study analysis of an organisation operating in an emergency context. The empirical validation showcased in a step-by-step fashion how an organisation can utilise the framework to enhance its organisational resilience. The individual recourses review exposed cognitive, emotional, behavioural and social capabilities of employees that facilitate organisational performance. The organisational resources audit brought to light organisation's collective cognitive, emotional, behavioural, relational and sociomaterial capabilities. The inspection of the organisation's environment highlighted the important stakeholders and relations with them. In result, the multilevel review phase revealed organisational vulnerabilities, in particular that an organisation should test its response capacity towards a terrorist attack and confidential data loss. The multilevel analysis and assessment of the two responses unmasked different individual and organisational capabilities as well as relations with environment that were crucial to respond correctly to adversities (strengths), and allowed indicating areas that require adjustment (single loop learning) or transformation (double loop learning). In addition, through this practical application, we demonstrated that the framework could be used along with mix-method approaches that combine both qualitative and quantitative elements, and thus give more holistic analysis. Furthermore, we proved that the framework is able to detect various organisational vulnerabilities and can be employed to test organisational preparedness to different types of crises. In fact, this highlights the breadth and flexibility of the framework application, which makes it a strongly valuable tool. In addition, we underlined the importance of the continuous approach to framework application in order to embrace organisational dynamics, including enhancing resilience. As demonstrated in our framework, the continuous approach allowed better monitoring of changes in internal and external organisational context, namely detecting weak signals and environmental pressures,

and thus keeping awareness and sensitivity. It also enabled verifying if the lessons developed in the past were actually learnt at multiple levels.

Drawing on the findings on the simulation, we will present now how our framework could be used to expand future research on organisational resilience. The framework highlights multilevel learning as an important next practice towards organisational resilience. Existing literature underlines that learning is a very contextual and non-static process (Haunschild et al., 2015; Madsen & Desai, 2010). Therefore, future studies should consider investigating and measuring the long-term effects of resilience enhancement through multilevel learning processes. Further, the framework addresses enhancing resilience through comprehensive preparedness, and multilevel responses. In this regard, future research should also take up the challenge to apply multilevel approach to enhancing resilience through recovery. In addition, as part of the path to improving organisation resilience, the framework proposes analysing multilevel capabilities of an organisation (individual and organisational level), and in particular it highlights common inter-level cognitive, emotional, behavioural, and relational dimensions. Up to date, measuring within and cross-level direct effects between the dimensions and organisational resilience remain under-investigated. For instance, as part of the future explorations, researchers could examine how adjustments in collective emotions affect organisational resilience or how rearranging of individual mental models affect organisation's crisis preparedness and responses. The framework validation aimed to test its usefulness in practice and highlight its advantages of broad and flexible application. In this matter, it is important to underline that practical application of the framework should be always adjusted to the context as well as allocated resources. We encourage both researchers and practitioners to put the framework into practice in different industry and organisational contexts to build and expand the comprehensive list of methods to review and analyse multilevel elements, and share next practices on multilevel learning processes. We believe that the framework along with its

future fruits will constitute an insightful base of knowledge and tools for crisis and resilience management.

4.6. Concluding Remarks

To conclude, organisations are complex systems that require multilevel management efforts to remain resilient. Although researchers acknowledged that resilience is a dynamic process that rises at multiple levels, there has been a lack of studies that specifically examined and addressed those challenges in theory and practice. In response to those complexities, we applied the multilevel approach to design a new framework with which an organisation can self-assess its crisis preparedness and response capacity, and learn to enhance resilience. We advanced resilience and crisis management theory by incorporating in the framework the multilevel review and analysis of organisation's context, crisis responses, and learning processes. Focusing on the individual, organisational and environmental levels, the framework shows in four phases how to enhance resilience through identifying vulnerabilities, testing preparedness, analysing response capacity, and strengthening capabilities. Due to the dynamics of organisational processes, we highlighted that resilience management requires a continuous approach in applying the framework. We validated the framework with an empirical study, and described each framework application phase to present how it can be put into practice. Finally, we discussed the advantages of multilevel and continuous approaches, and identified the future research areas. By introducing the framework that applies multilevel and continuous approaches, we believe it is a promising path towards building more thorough crisis and resilience management theory and practice.

5. Conclusion

This dissertation has addressed major challenges of understanding of resilience from the social science perspective, focusing on informational relations as well as multilevel organisational structures and management mechanisms. In this light, the dissertation investigates different empirical contexts to better understand social resilience and find the ways to enhance it. As noted earlier, the research results significantly contribute to both theory and practice of resilience and crisis management studies. More specifically, by introducing new conceptualisation of organisational interdependencies the dissertation answers how interdependencies affect resilience in organisational systems. Next, it proposes a concept of informational capital to explain how organised trust-based interactions and information dissemination can enhance disaster resilience. Finally, this dissertation establishes the multilevel framework that helps organisations in enhancing their resilience by identifying vulnerabilities, testing preparedness, analysing response capacity, and increasing their capabilities by practice and learning.

The overarching theme of thesis is social resilience regarded as a critical feature of organisations and communities that allows effective mobilisation of accumulated resources and capabilities to overcome the unexpected disruptions. The thesis chapters showcase a variety of factors that shape social resilience and how social resilience is constructed in different contexts. In particular, all case studies highlight that social resilience is formed by social relations, their structures and context as well as flow of information. The studies present also the evolution of my research thought on constructing social resilience from exploring the role of informational relations in disaster resilience, through investigating the influence of formal and informal structure on resilience, to proposing a practical framework for enhancing resilience. The results of all chapters also confirm that social resilience emerges from the flow of information and its

effective use in the time of crisis. All thesis sections also emphasise the importance of multilevel dynamics, which were in detail explored at individual, organisational, and environmental levels. Furthermore, all case studies leverage on each other's results in highlighting the importance of informal relations in enhancing social resilience by boosting trustful communication processes and increasing resilience management efficiency.

The concepts and framework introduced in thesis gave the comprehensive understanding how social resilience is constructed, however, there are several limitations of the research that should be highlighted. First, the empirical study that uses multilevel interdependencies concept for organisational resilience analysis was focused on major disruptions in targeted and random scenarios. Furthermore, the structure of organisational interdependencies was embedded in the specific context, which shapes the perceptions and behaviours of the involved actors. Therefore, the generalisation of simulation results to other size and type of disruptions as well as organisational contexts is limited.

Next, although the concept of informational capital was sufficiently introduced, it certainly requires further elaboration beyond what is examined in the paper. The research on informational capital explored its formulation in a specific disaster management context, i.e. volcano eruption in a developing country. The ways how informational capital is formulated might vary in countries with different socio-economic conditions.

Lastly, the multilevel framework for enhancing organisational resilience highlights the importance of learning. Although, existing literature underlines that learning is a very contextual and non-static process, the research did not investigate application of the framework in other organisational contexts neither it measured the long term effects of learning processes. The framework validation aimed to test its usefulness in practice and highlight its advantages of broad and flexible application. In this matter, it is important to underline that practical

application of the framework should be always adjusted to the context as well as allocated resources.

Although this dissertation sufficiently explored the grounds of social resilience and proposed the ways to enhance it, certainly there are several directions how the contributions could be expanded. Hence, future research should take up the challenge to broaden the study of multilevel organisational interdependencies with cross disciplinary analyses of other organisational contexts and larger samples in order to build up explore how the interdependencies are shaped in different organisational systems and how they affect system performance. These future analyses, along with the thesis results should be the insightful base of next practices for resilient design and management of organisations. The thesis encourages also future research to modify the simulation settings and presented model of organisational interdependencies, and showcase how multilevel interdependencies affect resilience in other size and type of disruptions.

Next, future research should continue to tease out the ways in which informational capital facilitates community disaster resilience at various scales and in more complex situations. In similar direction, researchers should also explore new quantitative approaches to assess and measure the impact of informational capital on building community disaster resilience at multiple levels.

Lastly, future studies using the multilevel framework to enhance organisational resilience should consider investigating and measuring the long term effects of resilience enhancement through multilevel learning mechanisms. The framework addresses enhancing resilience through comprehensive multilevel preparedness and responses. In this regard, future research should also take up the challenge to apply multilevel approach to enhancing resilience through recovery. The thesis also should inspire both researchers and practitioners to put the framework

into practice in different industry and organisational contexts to build and expand the comprehensive list of methods to review and analyse multilevel elements, and share next practices on multilevel learning processes. In this way, the framework along with its future fruits will constitute an insightful base of knowledge and tools for resilience management.

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Appendix 1

Table A.1. Simulation parameters

Relations	Aggregated edge type	Contained network edges	No. of existing multiplex links	Weight	Speed	Share of other agents resources in disruption condition (directional)	Contribution to 2-step resource sharing
Formal	Rep_single	Single reporting	55	0.2	40	0.4	.
	Rep_mutual	Mutual reporting	3	0.4	45	0.4	.
	Superv	Authority	6	0.6	50	.	.
	Superv_rep_single	Authority, Single reporting	52	0.8	55	0.4	.
	Superv_rep_mut	Authority, Mutual reporting	4	1.0	60	0.4	.
Informal	Acq	Acquaintance	15	0.1	5	0.2	Step 1 + T_D
	Friend	Friendship	12	0.3	10	.	Step1
	Acq_friend	Acquaintance, Friendship	17	0.4	15	0.2	Step1
	Famil	Familiarity	28	0.6	20	.	Step1&2
	Acq_famil	Acquaintance, Familiarity	6	0.7	25	0.2	Step1&2
	Friend_famil	Friendship, Familiarity	11	0.9	30	.	Step1&2
	Acq_friend_famil	Acquaintance, Friendship, Familiarity	8	1.0	35	0.2	Step1&2

Appendix 2

A) 1-step resource sharing in normal condition

- Agent F needs a resource of agent S ($T_D:[S]$): agent S gives resource to agent F because they are connected by an acquaintance edge (acq) and agent S has agent F on his task demand list ($T_D:[F]$); Transfer time = $100 - 5 = 95$
- Agent S needs a resource of agent L ($T_D:[L]$): agent L gives resource to agent S because they are connected by a single-way reporting edge; Transfer time: $100 - 40 = 60$

Figure B.1. One-step resource sharing in normal conditions.

B) 2-step resource sharing in normal condition

Scenario: Agent F needs a resource of agent L ($T_D:[L]$), as they are not directly connected, he asks agent S for help.

Step 1: If agent S and agent F are connected by an instrumental tie, i.e. acquaintance (acq), agent S will facilitate resource sharing only if agent's F resource is on his task demand list (T_D), that is when the fair exchange can take place. In case of other informal links the resource connection will be directly facilitated.

Step 2: Agent S can ask agent L for a favour to help agent F only if they are connected by strong instrumental and expressive ties, i.e. containing familiarity component (famil, acq_famil, friend_famil, acq_friend_famil)

Figure B.2. Two-step resource sharing in normal conditions.

C) Disruption

Scenario: Agent F's task demand is resource J (agent J). Agent J is disrupted (not available).

- 1) Agent F has initial 20% of needed resource of agent J due to the informal connection (acq_friend_famil) comprising exchange of work-related information (component of 'acq')
- 2) As agent J reports to agent S, agent F asks agent S for additional 40% (superv_rep_one_way). There is also a parallel informal link which facilitates faster transfer; Transfer time = $100 - (55+10) = 35$
- 3) Because agent F and agent S share strong expressive ties (friends) and agent S and H share strong expressive and instrumental tie (famil), agent S asks agent H for a favour to help agent S with missing resource part (40%); Transfer time = $(100 - (55+10)) + (100-20) = 35 + 80 = 115$

4) Total transfer time: 150

Figure B.3. Resource sharing in disruption conditions.

Appendix 3

Table A. Individual degree

Agent Id	Org.	Unit	Formal Individual Degree	Informal Individual Degree
1	A	A3	1.4	4.2
2	B	B1	1.2	0.1
3	B	B	4.6	0.0
4	A/B	A/B	9.4	2.1
5	A	A1	1.8	2.4
6	A	A3	1.2	2.2
7	A	A4	3.6	1.3
8	B	B4	1.2	0.1
9	A	A1	1.0	2.8
10	B	B2	3.8	0.0
11	A	A4	2.2	0.0
12	B	B3	1.6	1.7
13	B	B1	0.8	0.0
14	A	A3	8.0	4.9
15	A	A3	1.0	0.8
16	B	B1	1.0	3.9
17	A	A1	6.4	1.2
18	B	B1	0.8	2.9
19	A	A2	1.2	5.6
20	A	A3	4.8	0.1
21	A	A2	1.8	0.9
22	B	B1	1.2	4.2
23	A	A	5.6	0.0
24	B	B	0.4	0.0
25	A	A3	0.8	3.6
26	A	A3	0.8	1.5
28	A	A3	1.2	4.2
29	A	A3	1.8	2.6
30	A	A4	0.8	0.4
31	B	B2	1.0	2.4
32	B	B1	1.0	0.2
33	B	B3	6.0	1.1
34	A	A2	5.2	2.0
35	A	A3	1.2	4.2
36	A	A3	5.4	4.3
37	A	A4	1.0	0.8
38	B	B3	1.8	6.6
39	B	B2	0.2	0.0
40	A	A3	1.2	0.4

41	A	A4	2.2	0.8
42	B	B2	0.8	0.0
43	B	B3	1.4	1.1
44	B	B3	1.4	3.1
45	B	B1	1.6	3.5
46	B	B1	6.4	0.0
47	B	B1	0.4	0.0
48	A	A1	1.6	3.4
49	A	A4	2.6	2.9
50	B	B	0.4	0.0
51	B	B2	1.6	2.3
52	B	B2	1.4	3.0
54	A	A2	1.2	2.7
55	B	B4	2.2	0.5
57	B	B3	2.2	2.6

Table B. Intraunit degree

Unit	Formal Intraunit Degree	Informal Intraunit Degree	Number of Individuals	Average Formal Intraunit Degree	Average Informal Intraunit Degree
A	0.4	0.0	2	0.20	0.00
A1	6.8	5.0	4	1.70	1.25
A2	4.8	1.8	4	1.20	0.45
A3	25.2	27.4	12	2.10	2.28
A4	6.4	2.4	6	1.07	0.40
B	1.6	0.0	2	0.80	0.00
B1	12.4	8.2	9	1.38	0.91
B2	7.6	3.0	6	1.27	0.50
B3	10.8	7.6	6	1.80	1.27
B4	3.2	0.2	4	0.80	0.05

Table C. Interunit degree

Unit	Formal Interunit Degree	Informal Interunit Degree	Number of Individuals	Average Formal Interunit Degree	Average Informal Interunit Degree
A	11.0	1.1	2	5.50	0.55
A1	4.0	4.8	4	1.00	1.20
A2	4.6	7.9	4	1.15	1.97
A3	3.6	4.4	12	0.30	0.37

A4	6.0	3.8	6	1.00	0.63
B	6.6	1.0	2	3.30	0.50
B1	2.0	6.6	9	0.22	0.73
B2	1.2	3.5	6	0.20	0.58
B3	3.6	7.1	6	0.60	1.18
B4	1.0	0.4	4	0.25	0.10

Table D. Intraorganisational degree

Org.	Formal Organisational Degree	Informal Organisational Degree	Number of Individuals	Average Formal Organisational Degree	Average Informal Organisational Degree
A	72.8	58.6	28	2.60	2.09
B	50.0	37.6	27	1.85	1.39

Table E. Interorganisational degree

Interorg. network	Formal Interorg. Degree	Informal Interorg. Degree	Number of Individuals	Average Formal Interorg. Degree	Average Informal Interorg. Degree
<i>m</i>	0.0	2.7	54	0.00	0.05

Appendix 4

Figure A. Model of acquaintance network. Node size represents node in-degree centrality. Fruchterman-Reingold layout algorithm.

Figure B. Model of friendship network. Node size represents node in-degree centrality. Fruchterman-Reingold layout algorithm.

Problem-solving

Figure C. Model of problem-solving network. Node size represents node in-degree centrality. Fruchterman-Reingold layout algorithm.

Motivation

Figure D. Model of motivation network. Node size represents node in-degree centrality. Fruchterman-Reingold layout algorithm.

Appendix 5

Table A. “Secret” Data Loss Scenario—sample of excerpts showing how cues were coded and abstracted into levels and categories.

Category	Subcategory	Questionnaire Excerpt*
<i>Individual-level</i>		
Cognitive Capabilities	Sensemaking	<i>It would be best not to jump to conclusions and exacerbate the situation without concrete information. (Respondent #1, Role 2)</i> <i>[I will] double check the fact with colleague public (Respondent #3, Senior Staff, Role 2)</i> <i>Losing "Secret" data is serious. If the information were to be leaked, there could be serious ramifications (e.g. alarm or even panic in the public (Respondent #1, Role 2)</i>
	Prior experience	<i>I have managed similar issues at a lower level severity. So there has been past experience.</i>
Behavioural Capabilities	Personal mastery	<i>[I am able to] keep the clarity of mind to deal with crisis situations (Respondent #9, Role 1)</i>
	Acting fast	<i>A crisis will not be a crisis if it can be anticipated. Therefore my role involves raising requests and coordination with the stakeholders. I need to act fast in order to contain the situation. We cannot afford to be "Brain frozen" when face with high stakes. (Respondent #21, Senior staff, Role 3)</i>
	Commitment	<i>[I will do] any task that aims to protect the integrity of the organization and the country. (Respondent #6, Senior staff, Role 1)</i>
	Weak signals detection	<i>It is vital to the [organisational] system and nation that secret information are to be kept by a trusted person, which means the person must be able to execute his/her job well. If I were to observe that the said person is behaviour below his/her baseline level, it would definitely be of concern. While I may not be able to probe further, I believe the right thing to do is to flag it up to my superior as that they would be able to make more informed decisions regarding the matter. (Respondent #15, Role 2)</i>
	Improvisation in uncertainty	<i>As there was not an incident that happened before, my response is rather common sense. (Respondent #2, Role 1)</i>

Emotional Capabilities	Empathy	<i>What I mentioned before were guesses and common sense in such situations based of what I heard before. (Respondent #1, Role 2)</i> <i>I would speak to him/her first before escalating the situation. It could be an honest mistake, where the personal issue has impaired his/her memory and ability to function at work. . (Respondent #1, Role 2)</i>
Relational Capabilities		<i>I am able to discern what to say and what not to. (Respondent #1, Role 2)</i> <i>I will seek colleague's consent to talk the supervisor. (Respondent #2, Role 1)</i>

Organisational-level

Collective cognition capabilities	Sensemaking	<i>We convene a meeting with relevant personnel to discuss possible scenarios and contingency plans if information is to be leaked. (Respondent #7, Role 1)</i> <i>We will gather the team together to figure out what is the best move forward. (Respondent #3, Senior staff, Role 2)</i> <i>I will communicate to the rest of the team to be extra careful on data protection (Respondent #13, Senior staff, Role 1)</i> <i>I get reminders from colleagues and bosses and relevant departments that secure storage of confidential information is important. (Respondent #19, Role 1)</i> <i>(...) security is different when you look at it from the [security services industry] perspective. (Respondent #15, Role 2)</i>
	Safety as culture	<i>It's part of the culture to know the importance of keeping data safe and the possible ramifications were it to fall in the wrong hands. (Respondent #1, Role 2)</i> <i>The information may potentially be misused and may threaten the security and reputation of not just my unit, but my organization as a whole. (Respondent #8, Role 1)</i> <i>There can be no full proof prevention for any crisis. There can only be good preparation measure to manage coupled with prevention strategies for early warning and damage mitigation. (Respondent #21, Senior staff, Role 3)</i>
	Procedures and organisational structure	<i>[I will] ensure the colleague who lost it has reported the situation to supervisor (Respondent #1, Role 2)</i>

Collective behaviour capabilities	Mindful leadership	<i>[I will] await for further instructions from management as mitigation/resolution of such crises do not fall within my purview. Follow-up investigations will be done by investigations officers once the police report is lodged and the usual standard procedures will be activated. (Respondent #18, Role 1)</i>
		<i>[I will] await further instructions from management and bosses so as to respond adequately and appropriately (Respondent #15, Role 2)</i>
		<i>As a supervisor, to ensure relevant facts are collected (to be fair to the staff involved) and relevant gaps are identified to prevent future happenings).... No point fault-finding or finger pointing as the priority is to uncover what has happened and prevent potential negative outcomes. There may be a need to manage the morale of the staff and team involved. (Respondent #13, Senior staff, Role 1)</i>
		<i>And all this requires trust between people in order to execute them efficiently and effectively). Build trust and psychological safely net for the team. (Respondent #21, Senior staff, Role 3)</i>
Collective emotion capabilities	Operations and operational support	<i>Support peers and assist in any investigation/recovery efforts, if any and if needed (Respondent #12, Role 1)</i>
		<i>We will set up a time line to figure out where the laptop was (Respondent #1, Role 2)</i>
		<i>Because we work closely as a team in day to day work, I will be equipped to help my colleagues when such a time arises. (Respondent #15, Role 2)</i>
	Operations uncertainty	<i>Apart from informing the authorities, there is no SOPs or formal processes involved for loss of confidential data. (Respondent #10, Role 1)</i>
Relational capabilities	Emotional support	<i>I will seek emotional support from [Role 2 employees] who I'm close to because we have shared personal issues and sought emotional support from each other before. (Respondent #1, Role 2)</i>
	Instrumental support	<i>I will ask for an advice colleagues I trust because it is easier to talk to them about it and to ensure that no leakage of information unless necessary (Respondent #2, Role 1)</i>
Sociomaterial capabilities		<i>I will ask some of the more senior [Role 1 employees] or immediate supervisor as they would be more experienced to deal with the situation (Respondent #20, Role 1)</i>
	Facilitating search	<i>Initiate a physical search for the laptop, reviewing security footage for suspicious activity. (Respondent #6, Senior staff, Role 1)</i>
		<i>Continue searching, hopefully it's still within the premises (Respondent #1, Role 2)</i>

Check 'recent files' folder to see if the document was open (should be password protected) in the last 15h (Respondent #9, Role 1)

Environmental-level

Information exchange and collaboration	Other security services organisations	<p><i>Alert [other security services organisations](...)</i> (Respondent #6, Senior staff, Role 1)</p> <p><i>Reporting it to law enforcement to commence investigations.</i> (Respondent #7, Senior staff, Role 1)</p> <p><i>Inform [relevant authority] of the lost of the laptop and request for review of CCTV at the time where it was last known, and access control check for [people] leaving the premise if necessary</i> (Respondent #21, Senior staff, Role 3)</p>
	Public	<i>Assess need to alert public if disclosure on loss of laptop might lead to public alarm and imminent danger</i> (Respondent #6, Senior staff, Role 1)
	Media	<i>Prepare a statement for media</i> (Respondent #6, Senior staff, Role 1)
Impact	Other security services organisations	<p><i>(...) embarrassment to [the other security services organisations] can have a negative impact on a national scale, as the implications would extend into political grounds (on top of security issues)</i> (Respondent #15, Role 2)</p> <p><i>The confidential data will have operational and reputational impact on [other security services organisations] if it were to be leaked to the public.</i> (Respondent #19, Role 1)</p>
	Public	<p><i>It is a secret document and the information within the document has a direct impact on the national security.</i> (Respondent#3, Senior staff, Role 2)</p> <p><i>[The loss will cause] embarrassment to and lost of public trust in Profession, Division, and Organization</i> (Respondent #12, Role 1)</p>

*Text in the square brackets was added to maintain excerpts meaning or rephrased due to protection of sensitive information.

Table B. Terrorist Attack Scenario—sample of excerpts showing how cues were coded and abstracted into levels and categories.

Category	Subcategory	Questionnaire Excerpt*
<i>Individual-level</i>		
Cognitive Capabilities	Sensemaking	<p><i>My role and duty would be to make sense of the information from the ground. (Respondent #16, Role 2)</i></p> <p><i>[I will] ascertain that the crisis is real. (Respondent #1, Role 2)</i></p> <p><i>Considerations are only involved when deciding on whether he/she is to be deployed. These include, in no order of priority: (i) ability to assist in operations; (ii) manpower requirements; (iii) safety of personnel. (Respondent #21, Role 1)</i></p> <p><i>I will link up with [the emergency response team] members (Respondent #10, Role 1)</i></p> <p><i>I will always tune into media to understand the situation and the sentiments among the various communities. (Respondent #25, Senior staff, Role 3)</i></p>
	Prior Experience	<p><i>I have prior experience supporting officers/families/MOPs in crisis situations such as line-of-duty injury, suicide, crime victim etc. (Respondent #8, Role 1)</i></p> <p><i>I have been researching on overseas terrorism cases as it happened in real time, so I have experience doing something similar (Respondent #3, Senior staff, Role 2)</i></p> <p><i>Prior experience in responding to crisis negotiation and critical incidents that allows for practice in self-mastery, and other relevant skills. (Respondent #7, Role 1)</i></p>
	Personal mastery	<p><i>[I will] take a moment to gather my thoughts (Respondent #14, Role 1)</i></p> <p><i>[I will do] self-preparation (i.e. mental, physical, relational - inform family of engagement). (Respondent #10, Role 1)</i></p>
Behavioural Capabilities	Acting fast	<i>The fast pace of work have helped me develop the skill of being productive under stress.</i>
	Commitment	<i>It is our duty as part of [security services sector] to assist in any way we can. Respondent #6, Senior staff, Role 1)</i>
	Flexibility	<i>I am able to manage differing priorities. (Respondent #5, Senior staff, Role 1)</i>

	Family role	<p><i>I will message my family and friends to ensure everyone is fine. (Respondent #25, Senior staff, Role 3)</i></p> <p><i>[I will] confirm the safety of my loved ones. (Respondent #15, Role 2)</i></p> <p><i>Find out if any of my family and loved ones are affected by the attack. (Respondent #13, Senior staff, Role 1)</i></p> <p><i>Notify my family of the activation (Respondent #8, Senior staff, Role 1)</i></p>
	Improvisation	<p><i>I'm guessing that I can provide PFA if necessary. [The response of Role 2 employees] is more administrative. However, if they need us to be on the ground or to provide information based on research, I think I can do that. (Respondent #1, Role 2)</i></p> <p><i>I will go where they need me to go and do what necessary (Respondent #2, Role 2)</i></p>
	Weak signals detection	<p><i>If the officer is to insist, I can only flag it up to my superior so that my superior can take note and make the necessary decisions, as my superior would have a better understanding of the situation on the ground (manpower and operations issue). (Respondent #16, Role 2)</i></p> <p><i>There is no consideration(s) required when it relates to highlighting such situation. (Respondent #21, Role 1)</i></p>
	Empathy	<p><i>[I am] concerned about the well-being of my colleague (Respondent #9, Role 2)</i></p> <p><i>Fulfilling the mission of [the emergency response team] should not be at the expense of the well being of a colleague. (Respondent #7, Role 1)</i></p>
Emotional Capabilities		
Relational Capabilities		<p><i>I will also explain to the colleague on why it is necessary he/she does not proceed with the activation and focuses on recovery first. (Respondent #7, Role 1)</i></p> <p><i>I am able to work well with others. (Respondent #5, Senior staff, Role 1)</i></p> <p><i>I will explain to my colleague that this is for the good of everyone, while acknowledging his/her keenness to play a part. (Respondent #8, Role 1)</i></p>
Organisational-level		
Collective cognition capabilities	Sensemaking	<p><i>Active listening is used in most aspects of the day-to-day work. (Respondent #12, Role 1)</i></p> <p><i>We understand [each other] and share similar mental model. (Respondent #25, Senior staff, Role 3)</i></p> <p><i>We will gather the team to analyse the case. (Respondent #3, Senior staff, Role 2)</i></p>

Collective behaviour capabilities	Safety as culture	<p><i>The welfare of team members should be of paramount importance not just because it concern toward a fellow colleague, but also in terms of operational capability. (Respondent #12, Role 1)</i></p> <p><i>Likely my immediate team mates on [the emergency response team] that I am on so that we watch out for each other's well being as part of team self-care. (Respondent #7, Role 1)</i></p> <p><i>Safety is of utmost importance. (Respondent #17, Role 3)</i></p> <p><i>[We] ensure our own people are well enough before risking life/health to save others. (Respondent #19, Role 3)</i></p>
	Procedures and organisational structure	<p><i>In any case, there is always a contingency system in place and there may be colleagues who can step in temporarily to cover the colleague is unwell. (Respondent #7, Role 1)</i></p> <p><i>Regularly update [the emergency response team] management. (Respondent #7, Role 1)</i></p> <p><i>The relevant protocol / Standard Operating Procedures (SOPs) will be activated and the team will be mobilized (...) (Respondent #21, Role 1)</i></p>
	Mindful leadership	<p><i>Staff well-being and safety are important. He/she may further jeopardize others in the course of work as others have to keep a close watch on him/he (Respondent #13, Senior staff, Role 1)</i></p> <p><i>It is important for the officers to practice self-care (Respondent #3, Senior staff, Role 2)</i></p> <p><i>(...) to prevent further disruptions to the activation. Officer's health comes first. (Respondent #23, Senior staff, Role 1)</i></p>
	Operations and operational support	<p><i>[the Role 2 employees] provide research inputs into the potential attack. (Respondent #3, Senior staff, Role 2)</i></p> <p><i>[The organisation] is supposed to respond by providing psychological support where needed. In addition, as a research outfit, [the organisation] is required to provide inputs to the operations of such crises. (Respondent #14, Role 2)</i></p> <p><i>I will get ready with team for duties in office. (Respondent #7, Role 1)</i></p>
	Operations uncertainty	<p><i>This is in view of the fact that if such an activation was to occur it will be the first of its kind and much uncertainty, confusion and chaos is to be expected i.e. high stress situation (...) This is a new area of work and much of the preparation and training for it is still being thought through and hence evolving, more details and information are still pending. (Respondent #7, Role 1)</i></p>

Collective emotion capabilities	Emotional support	<p><i>Some of other [Role 2 employees] (...), they are people who I would feel comfortable seeking emotional support from. Moreover, they have already provided emotional support in other situations. (Respondent #1, Role 2)</i></p> <p><i>Ensure that my fellow co-workers are coping alright with the news. (Respondent #9, Role 2)</i></p>
Relational capabilities	Instrumental support	<p><i>I feel that we have worked together and know each other socially. (Respondent #1, Role 2)</i></p> <p><i>Other colleagues will be those whom I share a personal connect and friendship with - this will be more to gain support as well as to support those whom I share a more intimate relationship with. (Respondent #7, Role 1)</i></p> <p><i>I would ask [for an advice] my closest colleagues. (Respondent #11, Role 1)</i></p>
Sociomaterial capabilities	Operations preparation	<p><i>We will set up social media scrapers. (Respondent #4, Role 2)</i></p> <p><i>Bring necessary equipment for activation (Respondent #6, Senior staff, Role 1)</i></p> <p><i>Prepare PFA and crisis response brochures (Respondent #8, Role 1)</i></p> <p><i>Prepare the materials required for response and (Respondent #21, Role 1)</i></p> <p><i>Prepare other necessities such as power bank and water (Respondent #8, Role 1)</i></p>

Environmental-level

Information exchange and collaboration	Other security services organisations	<p><i>We will assist and support [law enforcement] officers in their operations (Respondent #12, Role 1)</i></p> <p><i>Research on the case for example find out the motivations of the perpetrators, the implications of the attack and how we can help [the cooperating security services organisations] be more efficient in their response to similar incidents (Respondent #9, Role 2)</i></p>
	Public	<p><i>The intent is to work with existing community leaders to carry out Psychological First Aid to members of the community to manage and mitigate the psychological impact of such a terror attack, to bolster community resilience, to allay fears and minimise misinformation and rumour mongering. Linking the community with necessary resources to cope in times of crisis (i.e. through existing community champions) is the key role of [the outfit] (i.e. in the capacity of [emergency response] teams) in times of such event (Respondent #7, Role 1)</i></p> <p><i>Maintain communications with community leaders (Respondent #10, Role 1)</i></p>

Impact	Media	<p><i>Prepare media team to highlight act of heroism across the races, languages and religions to reinforce the [national] values. . (Respondent #25, Senior staff, Role 3)</i></p> <p><i>Monitor news feed (official source and public accounts)) to stay current and gain understanding of the general sentiments of the community (Respondent #12, Role 1)</i></p>
	Other security services organisations	<p><i>This event will likely impact [other security services organisations] and will affect the reputation of [the country]. (Respondent #10, Role 1)</i></p> <p><i>Trust in [security services] will be eroded (...). Trust in other emergency responses and medical support ... will also be influenced by their ability to cope with the casualties and ability to instil confidence and optimism in the community. (Respondent #12, Role 1)</i></p>
	Public	<p><i>Members of public were severely injured and the situation at hand is chaotic. It is our duty to assist in any way we can. (Respondent #18, Role 3)</i></p> <p><i>Impact/damage of the incident on the community and [country in general is expected to be pervasive, extensive (i.e., at all spectrum of the society, and at the micro- and macro-level), and lasting. (Respondent #12, Role 1)</i></p>

*Text in the square brackets was added to maintain excerpts meaning or rephrased due to protection of sensitive information.