Exploring Natech Risk Communication for Participatory Risk Management: Understanding citizens' communicative behaviour through a comparative study and a serious game

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参加型リスク管理のための Natech リスクコミュニケーションに関する研究：比較研究とシリアスゲームを通じた市民のコミュニケーション行動の理解

A dissertation submitted in partial fulfilment of the requirement for the degree of Doctor of Engineering

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Abstract

Active community engagement plays a central role in effective disaster risk reduction. Despite its wide recognition and numerous approaches, community involvement in disaster risk management processes still seems to be easier claimed than actually realised in most cases. In this regard, the contribution of effective risk communication is considered *sine qua non*. Promoting transparency throughout the decision-making process and disseminating risk information empowers all involved stakeholders to make risk-informed decisions. Considering the emphasis placed by current risk communication approaches on relationship-building among stakeholders, such practices seem to create favourable conditions for participatory disaster risk management, since they encourage community involvement and trust-building. Furthermore, recent approaches involving serious gaming—i.e., games that have purposes other than only entertainment—have gained considerable credit within the disaster risk management discourse as promising risk communication tools to promote public awareness and support participatory decision-making for risk-related issues.

These risk communication issues have only recently emerged considering large-scale, complex disasters, such as technological accidents triggered by natural hazards, also known as Natech. In cases where chemical risk communication is limited, individuals may find themselves in lack of necessary information crucial for their effective preparedness against and appropriate response during a potential accident. From a communication standpoint, such risk information deficiency creates a secondary meta-problem for individuals which stems from that initial problem, that is the exposure to the initial Natech accident risk itself. Risk perception studies have so far explored how that initial risk is socially experienced, however, this study ventures to investigate this secondary communication problem. In this context, this research aims to contribute to the emerging topic of Natech risk communication by expanding the current knowledge about citizens' communicative behaviour towards chemical risk information disclosure and further by proposing a serious game as a means to raise awareness about Natech accident risk and communicate about its management.

Focusing on the communication problem of lacking Natech risk information, this research initially explores the determinants and sociodemographic influences that shape individuals' situational perceptions and communicative behaviours. Japan and S. Korea have been selected for a comparative study in an attempt to identify and understand any potential differences in how individuals from analogous sociocultural backgrounds but embedded in different chemical risk governance systems communicate about Natech risk information disclosure. In particular, these two countries share a comparable collectivistic sociocultural structure in view of cultural dimensions, yet they present important institutional differences in terms of chemical and Natech risk communication. S. Korea has recently updated their regulatory framework for the management of technological accidents introducing requirements for public disclosure of chemical information, while Japan still has not.

This study approached the analysis of the public's communicative behaviour through the interpretative framework of the Situational Theory of Problem Solving (STOPS). Complementary to STOPS, we explored individuals' perceptions concerning the Natech risk, as well as their relationships with governments and companies in terms of trust and decision-making power. For the purposes of data collection, self-administered, anonymous, household questionnaire surveys were carried out in 2018 (Japan) and 2020 (S. Korea) targeting residential, urban districts near

prominent industrial parks in both countries: Higashinada (Kobe) and Sakai-Senboku (Osaka) in Japan, and Yeosu, Suncheon, Gwangyang and Ulsan in S. Korea. Structural Equation Modelling was employed to validate the conceptual models and analyse the results of the two surveys, while the differences between groups were assessed using inferential statistics. Regression analysis was used to investigate the influence of sociodemographic variables on factors that drive individuals' situational motivation to communicate about the issue.

The research findings suggest that Natech accident risk is perceived as a concerning issue in both countries. However, even though households from both countries acknowledge the Natech risk information deficiency as a serious issue, Japanese are significantly more constrained in resolving it through communicating. In comparison, S. Korean respondents seemed to be more communicatively active about it, and more confident in responding to potential Natech accidents. Perhaps the chemical risk information regulation framework in S. Korea has contributed positively in alleviating the problem of risk information deficiency. Also, trust in government and businesses and perceived decision power-sharing seemed to have a positive effect on citizens' situational motivation to communicate about Natech risk by reducing the perceived meta-problem of information deficiency. Finally, sociodemographic characteristics exhibited generally weak and—except for gender and age—insignificant influences on the factors that shaped citizens' situational motivation to communicate about the issue.

Considering these findings that demonstrated the individuals' motivation to become informed and communicate about Natech accident risk, and aligning with the current risk communication paradigm which promotes participatory approaches that extend the disaster risk management discourse to involve the public, this research explored the potential of serious gaming for Natech risk communication. This study proposed and developed EGNARIA: a novel, educational, role-playing board game considering earthquake and tsunami scenarios that might cause subsequent chemical accidents. Players try to survive by taking disaster preparedness actions and responding correspondingly to the natural and chemical hazards they face. The game is designed to raise community awareness about Natech accidents, and generate a discussion among stakeholders about risk management strategies, chemical information disclosure and risk-informed decision-making concerning Natech accidents. In order to assess the impact of the game a quasi-experimental design was employed with a questionnaire survey before and after the trial application with Kyoto University affiliates. Adhering to the conceptual approach so far in this research, the survey was structured based on STOPS measures to understand the game's influence on the participants' communication behaviour regarding Natech risk. The preliminary findings from the game trial suggest an overall positive reception from participants as an engaging, educational tool to introduce communities to Natech accident risk and discuss about its management. Participants noted that the game raised their awareness about Natech accidents, highlighted the importance of community participation and chemical information disclosure and positively affected their intentions to actively search for and share information about Natech risk.

In sum, this study attempted to explore the communicative meta-problem of Natech risk information deficiency and in doing so provide some rudimentary empirical evidence for risk managers to pursue and foster chemical and Natech risk information disclosure as a way to alleviate the secondary problem. Additionally, a novel serious game for Natech risk awareness was developed and tested to aid risk communicators in opening the risk management discourse to communities.

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Chapter 1 Introduction

1.1 Background

Active community involvement in disaster risk management is widely acknowledged as one of the key factors for effective disaster risk reduction. Nevertheless, unlike hard infrastructure which can be meticulously and precisely engineered for the purpose, engaging communities in disaster risk management processes has proven to be easier claimed than realised in most cases. Despite continuous and extensive efforts by international organisations, such as the United Nations, to develop sustainable programmes for disaster-resilient societies, participatory risk management schemes are still not the norm (Samaddar et al., 2017; Pandey & Okazaki, 2005). Approaching local communities as partners, engaging them in the disaster risk management process and integrating their perspectives and concerns during the risk identification, mitigation, and preparedness stages is vital (Briones, Vachon, & Glantz, 2018; Twigg & Mosel, 2017; Pandey & Okazaki, 2005).

The contribution of effective risk communication towards this goal has been explicitly emphasised by academics and practitioners alike, over the past few decades. It is essential to create new and support existing information exchange channels among institutional organisations and citizens [1]. Disseminating risk information allows all involved stakeholders [2] to make comprehensive and risk-informed choices (Klinke & Renn, 2010). Furthermore, fostering transparency and dissemination of risk information seems to create favourable conditions for participatory risk management as it encourages trust-building and community engagement (Figueroa, 2013; Klinke & Renn, 2010). Thus, it can be argued that extending such processes to the local people and adequately informing them about the potential risks, a higher level of disaster preparedness throughout the community can be attained.

The discussion around the contribution of community involvement in disaster risk management, however, gains specific importance in consideration of large-scale complex disasters, for instance technological accidents triggered by natural hazards, otherwise referred to as Natech. Natech are concurrent events that occur when there is a hazardous material release as a result

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[1] The term 'citizen' in this article refers to lay persons or social actors that comprise 'publics, social groups and communities' (Kennedy, 2016). This study uses the terms 'citizen', 'individual', 'person' and 'community member' interchangeably referring to the above concept, henceforth.

[2] According to Okada et al. (2018, p. 431), the term *'stakeholders'* refers to *'those who are affected by decisions and actions and those who influence the decisions and actions in the relevant context'*. Complementary to stakeholders stand researchers and facilitators, who should maintain a neutral position with regard to the issue, but are not uninvested or disinterested toward the outcomes. Henceforth, this term is used with this meaning for the rest of the dissertation.

from the impact of a natural hazard on installations that handle them (Krausmann, Cruz, & Salzano, 2017). They are defined as technological accidents caused by a natural hazard that involve the accidental release of hazardous substances (UNDRR-APSTAAG, 2020). Natech accidents are considered as typical low-probability, but high-impact events that entail severe and long-lasting damages (Masys et al., 2014). The scale of such extreme events is likely to overwhelm local and even state-level coping capacities, inhibiting emergency response mechanisms and further hampering recovery efforts in the long-term (UNDRR-APSTAAG, 2020; Eisner, 2014; Kawata, 2011).

Prominent examples of such Natech accidents include the following events. The first case involved numerous hazardous material releases triggered by the impact of Hurricane Katrina in 2005 (Cruz & Krausmann, 2009). The largest release incident was the oil spill at the Murphy Oil Refinery, which threatened over 1,800 households at the nearby residential neighbourhood (Santella, Steinberg, & Sengul, 2010). Overall, the subsequent accidental releases had severe social and economic consequences, caused significant environmental pollution (Santella, Steinberg, & Sengul, 2010; Cruz & Krausmann, 2009) and long-term health complications to residents (Picou, 2009). The second example involved multiple fires and explosions at oil refineries in the Sendai region triggered by the Great East Japan Earthquake and Tsunami (GEJET) in 2011. Residents from a 2km zone around the installations had to evacuate (WHO, 2018; Yu, Cruz, & Hokugo, 2017; Cruz & Krausmann, 2013), while the fires and explosions triggered additional fires at neighbouring chemical facilities (WHO, 2018). Apart from the tremendous economic impact on the chemical industry, the released hazardous materials directly threatened the nearby population due to toxicity or flammability, and created medium- to long-term concerns from the possible chemical contamination of the soil and/or the underwater aquifer (Cruz & Krausmann, 2013).

Natech accidents pose a systemic risk. When Natech accidents occur, they do not only impair considerably parts of the system, but may lead to a critical failure of the entire system and/or incur further damages to other functionally connected systems (Okada, Chabay, & Renn, 2018). Planning for potential Natech accidents in advance and considering their intrinsic complexities during the risk reduction and preparedness phase are seen as equally crucial as the development of effective post-event response and recovery strategies (Suarez-Paba et al., 2020). Moreover, a Natech accident, as a type of compound disaster[3] that unfolds into unknown risks, presents a massive challenge for risk management authorities (Eisner, 2014); one that cannot be simply disentangled from the general disaster risk management system. Therefore, the extent and severity of such complex disasters demand for multidimensional responses that include actors

[3] *'Compound disasters'* or *'cascading disasters'* refer to unexpected, successive or simultaneous disasters, that have amplified impacts on the physical and social environment (see Eisner, 2014; Kawata, 2011).

from the government, business and local community for the purpose of addressing the associated risk effectively (Shimizu & Clark, 2019; Shimizu, 2012).

As with any type of hazard, the involvement of community is central in Natech risk management. Even though this is gradually being recognised by researchers and practitioners, most studies so far focused on natural hazards. For example, they explored the significance of community-based disaster risk reduction (Shaw, 2016); the roles of local communities during natural disasters (Briones, Vachon, & Glantz, 2018; Twigg & Mosel, 2017; Bajek, Matsuda, & Okada, 2008); or building disaster resilience at the local level (Moreno & Shaw, 2018; Kwok et al., 2018). There are currently only a few studies that investigated issues related to risk communication and community engagement concerning Natech accidents (Yu, Cruz, & Hokugo, 2017; Yu & Hokugo, 2015; Funabashi, 2012; Cruz & Okada, 2008; Steinberg & Cruz, 2004). More importantly, recent comprehensive literature reviews noted that the field of Natech risk communication is still quite underdeveloped and called for further research (Suarez-Paba et al., 2019; Cruz & Suarez-Paba, 2019). The current study answers this call and hopes to contribute in advancing the academic area of Natech risk communication, while also providing useful input for Natech risk management and communication practices.

From a spatial planning and management engineering point of view, preeminent international organisations recognised the gap in our current disaster risk management systems, and advocated for more inclusive and transparent risk communication policies. In fact, the United Nations' Sustainable Development Goals (SDGs - UN, 2015) set as a target[4] for safe, resilient and sustainable cities and human settlements the pursuit for inclusive and holistic disaster risk management across all levels. Meanwhile, the Sendai Framework for Disaster Risk Reduction 2015–2030 (UNISDR, 2015), calls for prioritising disaster education and risk awareness strategies in order to communicate disaster risk information and knowledge with the public, and further enhance disaster risk governance platforms through fostering transparency and involving all stakeholders—and especially communities—in the disaster risk management process. Finally, the recent supplement to the Guiding Principles for Chemical Accident Prevention, Preparedness and Response (OECD, 2015) targeting specifically Natech accidents underscored that information regarding the chemical accident risk and potential triggering natural hazards should be communicated to the public. This study, acknowledging the contemporary needs in disaster risk

[4] Goal No. 11: *'Make cities and human settlements inclusive, safe, resilient and sustainable'*; target 11.b: *'By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels'* (UN, 2015, p. 22).

management and aligning with the priorities mentioned above, ventures to develop the field of Natech risk communication and explore new implementation tools.

Within the abovementioned context of Natech risk communication, the motivation for this research is founded on two pillars. First, the notion that a community's 'right-to-know' (Hadden, 1989; see Baram, 1984) is not only a simple legislative matter, but rather an empowering risk communication approach (Hadden, 1989). Strategic risk communication emphasises relationship-building through a continuous, civic dialogue on the basis of right-to-know initiatives in order to address public risk-related concerns and perceptions (Palenchar, 2008). However, a community's right-to-know is exactly that: a right. Communities are not always obliged to be aware of the risk they are subject to, but ideally, they should have the choice of exercising their right to know. Thus, the second pillar is the argument that effective risk communication is not only about what risk experts believe citizens need to know, but also about what they actually want to know (Klinke & Renn, 2010).

It is worth noting that this study adopts an '*interpretive/critical research*' perspective (Bean, 2021) as far as Natech risk communication is concerned. Following the discussion of Zoller and Kline (2008), instead of a positivistic approach that focuses on evaluating the 'rightness' or 'wrongness' of communication messages against some 'objective' reality, interpretive/critical research engages in a '*double hermeneutic*' (Giddens, 1986) process of interpreting others' interpretations of sociocultural phenomena. Of course, this approach acknowledges that risk perception and communication are elements that are socially constructed (see Breakwell, 2007; Douglas & Wildavsky, 1982). Hence, this study seeks to provide an in-depth analysis and interpretation of a discourse to shed some light on the multidimensional ways in which risk communication fosters particular meanings to individuals (Bean, 2021; Zoller & Kline, 2008).

Finally, this study's research approach endeavours to go beyond the traditional *modus operandi* of disaster risk management, which involves top-down and centralised decision-making processes usually carried out by risk experts and government authorities (Solinska-Nowak et al., 2018). Such '*command and control*' methods tend to minimise community participation and partnership in decision-making and are often insensitive to local sociocultural norms or economic needs (Mechler, 2016). Even though they are arguably efficient for straightforward and 'structured' issues (Hurlbert & Gupta, 2015), such as deciding the height of flood control dykes, for more complex problems, such as managing Natech accident risks, such technocratic approaches may be perceived as unsuitable and potentially impractical by affected and exposed communities, impeding both risk communication and trust-building (Solinska-Nowak et al., 2018; Mechler, 2016). Acknowledging such impediments to effective risk communication, researchers and practitioners

during the last decade or so progressively shifted away from the rigid, purely scientific approaches towards more participatory and community-based disaster risk management strategies (Solinska-Nowak et al., 2018; Yamori, 2008, 2012; Clerveaux, Spence, & Katada, 2008). These participatory approaches do not view communities simply as recipients of disaster risk information, but as collaborators in a co-learning environment, based on processes and products that reflect their own contributions (Roncoli, 2006).

In fact, the communication gap between science-based risk assessment and disaster risk reduction practices has become an increasingly important issue nowadays, while research has only started to address some of the emerging challenges in this field (Gaillard & Mercer, 2013). Serious gaming-based methods (i.e., games that have educational purposes, and are not simply for entertainment) have recently started to be employed in the context of disaster risk management with promising outcomes (for a review see Solinska-Nowak et al., 2018). Several researchers have developed and successfully applied serious games for various disaster-related scenarios aimed at enhancing citizens' understanding of disaster risk management activities, encouraging collaborative decision-making, sharing hazard-related information and raising community awareness (Taillandier & Adam, 2018; Mossoux et al., 2016; Pereira, Prada, & Paiva, 2015; Meesters, Olthof, & Walle, 2014). Aligning with this new epistemological paradigm, this study tries to understand Natech risk communication and information disclosure from the perspective of communities, taking into consideration sociocultural influences, and further address potential implementation gaps from an empowering and collaborative angle via serious gaming.

1.2 Research Aim and Objectives

The overarching aim of this research is to contribute to Natech risk communication via expanding our current understanding through a cross-national, comparative study of how citizens communicate about Natech risk information disclosure, and further by exploring the potential of serious gaming as a participatory tool for Natech risk communication and meaningful community engagement. In more detail, this study ventures to investigate the communicative behaviour and perceived challenges of households in Japan and S. Korea concerning the issue of Natech risk information disclosure. In this context, the study focuses on illuminating the dimensions that shape the community's perceptions and communicative behaviour regarding chemical and Natech risk information disclosure, and also evaluating any influence from sociocultural factors. Furthermore, the study aims to include the development of a novel Natech risk communication approach based on a serious game. This educational game is intended to become an experiential, co-learning tool that introduces and enhances risk communication and collective decision-making among

stakeholders, targeted at raising awareness and literacy about Natech accident risk, appropriate preparedness measures, and the importance of risk information disclosure.

The main research questions explored in this study are presented below.

What are the effects of pursuing chemical accident risk communication in citizens' communicative behaviour and their relations with involved organisations concerning the issue of Natech risk information disclosure?

Could serious gaming be applied to raise Natech risk awareness and stimulate stakeholder engagement in disaster risk management?

In this framework, the main research aim is to investigate whether residents near prominent industrialised regions in Japan and S. Korea are motivated to communicate concerning Natech risk information disclosure, what are their perceptions and how they communicate about it. As an exploratory study on the subject of citizen motivation for risk communication, the intention is to explore from a cross-national perspective the reasons behind the community's attitude towards Natech risk communication, shed light on the communicative problem-solving actions residents engage in when trying to address the issue and help develop hypotheses for future research. On the other hand, considering the methodological novelty this research presents by using the *Situational Theory of Problem Solving (STOPS)* as a conceptual framework to conduct a cross-national study in the field of chemical and Natech risk communication, a secondary academic goal arises as well; to evaluate the interpretative power of this methodological framework in explaining publics' communicative behaviours pertaining to Natech risk communication issues.

Moreover, STOPS is used as the primary conceptual building block to investigate community perceptions and challenges regarding chemical and Natech risk communication. However, drawing from the *Organisations-Public Relations (OPR)* literature, the notions of '*Organisational Trust*' and '*Control Mutuality*' are introduced to the situational perception part of the model as representative dimensions of the relationships among citizens and the involved government institutions and industrial companies. Since these concepts are 'borrowed' as conceptualised from the view of OPR, they may offer an alternative approach to measuring such aspects. Their influence on citizen's situational perception and motivation to communicate about Natech risk is tested.

In addition, this study considers the effects of sociodemographic factors on Natech risk perception by approaching them through the interpretative framework of STOPS. Following this logic, key sociodemographic characteristics are considered as determining factors of citizens' situational perception, motivation to communicate and available ideas for solution. It should be acknowledged that in this way these variables are not measured in direct relation to Natech risk perception, but rather as controlling variables of the situational perception pertaining to the risk information deficiency *meta-problem*. This study focuses on demographic variables in an attempt to contribute to this discussion from a novel perspective.

Finally, transcending the traditional risk communication paradigm that dictates sharing information to raise community awareness concerning potential hazards and preparedness measures, the study proposes the development of *EGNARIA*, a novel serious game designed to train participants critical thinking skills for various scenarios. Participants, in particular, are expected to benefit from learning to anticipate circumstances and enrich their decision-making criteria to adapt their actions accordingly in preparation or response to such Natech events. Additionally, the proposed educational game will support a more participatory risk communication approach for Natech accidents based on mutual learning and opinion plurality able to guide risk management towards stakeholder inclusivity and collaborative decision-making. The serious game is tested with a quasi-experiment and assessed using an original survey based on STOPS in order to evaluate the game's reception, educational impact and changes in intended communicative actions.

The contribution of this study has both scientific and practical implications. On the one hand, from an academic standpoint, it frames and analyses a *meta-problem* of risk communication. Instead of looking at citizens' perceptions about the initial Natech accident risk, this study delineates for the first time a secondary problem of *information deficiency* about the Natech accident risk and attempts to understand it through STOPS. Moreover, it aims at evaluating the suitability of STOPS for risk communication analysis about complex disasters, such as Natech accidents, and for carrying out a cross-national study on risk communication. This methodological framework has not been employed under these conditions, making this a pioneering study in this regard as well. The study aims to highlight the residents' concern about the absence of adequate Natech risk information in Japan and S. Korea and shed some light upon the perceived underlying causes of this problematic situation from the citizens' perspective through their comparison. In addition, further expanding the scientific knowledge in the field of Natech risk communication, this study introduces in the field of disaster risk communication two key measures from organisation-public relations assessment research, namely Organisational Trust and Control Mutuality, in a novel

attempt to investigate the potential influence of such relationships on citizens' motivation to communicate about Natech risk. Moreover, this study examines social and cultural aspects to determine potential linkages that would warrant further research. Finally, an original serious game for Natech accident risk is proposed and developed, along with the design and implementation of a unique survey instrument in order to evaluate its impact with regards to the communicative behaviour of participants.

On the other hand, from a spatial planning and management engineering point of view, the study foremost develops and tests a novel serious game for Natech risk communication. Although there is always room for further improvement, the serious game is fully functional and ready for deployment in its current state. As a tool, EGNARIA aims at raising community awareness about Natech risk, highlighting the importance of risk communication and generating a discussion among stakeholders concerning chemical and Natech risk management. Additionally, the questionnaire instruments developed and tested over the course of this study can be potentially employed by risk management authorities in order to assess communities' perceptions and intended communicative behaviour about Natech risk and information disclosure. Such insights on community (mis-)perceptions regarding chemical and Natech accident risk can inform urban design and spatial zoning policies by delineating areas where public concern is high and could be prioritised in urban development and social welfare programmes. Moreover, methodologies that support citizen participation in decision-making processes for community commons, invite feedback, and improve the cooperation climate between all stakeholders can go a long way in assisting urban managers with understanding better and addressing the actual needs of residents. Overall, the aspiration is that the emergent findings concerning how people communicate about Natech risk information emphasised in the current study will set the basis for policy guidelines to improve risk information dissemination and encourage community participation in risk management processes in Japan and elsewhere.

1.3 Research Framework

The current research project ventures to examine from a cross-national standpoint the community 'appetite' for Natech risk information disclosure and risk communication, as well as to understand the communicative behaviour patterns and perceived challenges in the Japanese and Korean contexts through the prism of the *Situational Theory of Problem Solving (STOPS)*. This framework, traditionally employed in the domain of public relations, can be particularly helpful in appreciating what are the citizens' opinions about this secondary issue of chemical risk information deficiency by measuring their situational motivation to communicate. Additional factors such as trust and decision-making power are examined to assess the importance of establishing and

maintaining favourable organisation-public relations for Natech risk communication. A cross-national comparison has been selected in order to identify and elucidate the influential factors that shape community perceptions and drive communication so as to inform Natech risk communication research and policy. These two countries offer an advantageous comparative background because of their cultural similarities, but notable differences in their regulatory frameworks and approach considering chemical accident risk management, as discussed in later chapters.

Next, an in-depth analysis of the potential effects of the sociocultural context on shaping citizens' risk communication behaviour is conducted. The reasoning for this is to determine whether cultural aspects play an important role in how people communicate about Natech risk and information disclosure. Such findings are valuable in assessing the risk communication audience and informing risk communication strategies accordingly. There is a growing interest in risk perception and communication studies in cross-cultural issues, so this study hopes to contribute to this discourse from this perspective.

The final step is informed from the findings of the previous analysis and builds upon the established motivation of communities to communicate proactively concerning Natech risk, by proposing a novel way to reach out to non-experts and encourage communication and participation in Natech risk management processes. Hence, this study attempts to explore the potential of serious gaming as an effective approach for Natech risk communication. With this aim, a novel serious game, EGNARIA, is developed in an attempt to advance risk communication concerning Natech accidents. The study contributes to the academic discourse of risk communication through exploring and testing this novel workshop methodology with the use of the STOPS framework to assess and understand its impact on communicative behaviour about Natech risk. Also, from a practitioner's perspective, the development of a serious game targeted at raising Natech risk awareness and encouraging stakeholder engagement is quite important.

1.4 Dissertation Outline

After this introductory chapter, this dissertation is structured as follows. Chapter 2 presents a concise review of existing literature about chemical risk communication and information disclosure for participatory risk management, as well as an overview of regulatory frameworks that govern access to such information, both internationally and in Japan and S. Korea. Chapter 3 examines the cross-national investigation of citizens' communicative behaviour between Japan and S. Korea. It introduces the methodological framework of STOPS along with elements of organisation-public relations and additional factors that influence public risk perceptions. Chapter 4, then, analyses the effects from sociodemographic factors on citizens'

communicative behaviour about Natech risk information based on the cross-national comparison of Japan and S. Korea. Chapter 5 introduces EGNARIA, the novel serious game for Natech risk awareness, discusses its trial application and impact on communicative behaviour, as well as its contribution as a tool for Natech risk communication. The final chapter summarises the findings and considers study limitations and future research prospects.

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Chapter 2 Literature Review

2.1 Risk Communication and Chemical Information Disclosure

Societies need the means to communicate among their members concerning present, emerging and evolving risks (Sheppard, Janoske, & Liu, 2012). Therefore, in order to deal effectively with hazards, a society requires—in essence—a way to exchange risk-related information, so as to coordinate efficiently the available resources and prepare in advance to facilitate the response to a potential scenario. Covello (1992, p. 359) described risk communication as the '*exchange of information among interested parties about the nature, magnitude, significance, or control of a risk*'. Risk communication is regarded as an automatic, yet essential, method for societies to exchange information about a given risk, understand the situation at hand, deliberate and build stakeholder consensus concerning the appropriate course of action for effectively addressing it (Palenchar & Heath, 2007). The discipline of risk communication itself, Palenchar (2008) noted, gradually developed from the practical needs of industrialised societies to protect their citizens' lives and properties from natural and technological hazards.

Originally, disaster risk communication was understood as a *technical* process, entailing the unidirectional transmission of information from the authorities responsible for the management of risk to the public (Glik, 2007; Gutteling & Wiegman, 1996). This meant that risk communication initially was employed by experts with the aim of *convincing* lay audiences of their risk assessments (Hadden, 1989), thus effectively reducing risk communication messages to digested versions of technical information and public instructions. In contrast, the more recent approach of risk communication is based on social dialogue, stakeholder engagement and sharing of decision-making power (Gutteling & Wiegman, 1996); the interest is shifted from the quality of information to the quality of social relationships (Palenchar, 2008). This *democratic* view sees risk communication as an interactive and multidirectional process of information exchange (Glik, 2007). Information concerning the potential effects from an event and how various actions may affect the outcomes is shared via the communication channels among all involved stakeholders with the purpose of minimising the impact on human health and the man-made and natural environment (Bradley, McFarland, & Clarke, 2014). In this vein, the ultimate goal of risk communication is to empower community members at risk to make informed decisions in order to protect themselves and their properties (Bradley, McFarland, & Clarke, 2014).

Exchange of information between experts and community stakeholders is widely recognised as the core of risk communication. Naturally, the features of the messages and the strategies employed to convey them play a crucial role in shaping the opinions and perceptions of involved parties. Risk perception, after all, is the outcome of acquiring, selecting and interpreting

environmental signals related to the potential consequences of events, activities or technologies characterised by uncertainty (Wachinger & Renn, 2010). Communication in this context attempts to bridge the gap between the more 'objective', technical definition of risk as understood by experts and its subjective, social construct as experienced by the wider community. Over the years, risk communication has been highlighted by research scholars as the *sine qua non* for stakeholder involvement and risk governance (Renn & Klinke, 2013; Aven & Renn, 2010; Renn & Walker, 2008), and particularly so in the context of industrial, nuclear and environmental accidents (Palenchar, 2008; Shapiro, 2005).

Needless to say, open access to information is a precondition for its exchange between involved parties. In this regard, information disclosure is intrinsically connected to risk communication. Yet, pursuing chemical risk information disclosure policies is not always such a straightforward decision for risk managers. This key challenge remains unresolved to this day, as disaster risk communication becomes particularly relevant for residents and employees, who live near or work at industrial facilities that handle potentially hazardous materials. There seems to be no general consensus about the matter, as researchers and practitioners have often argued against chemical risk information disclosure, claiming various issues from inciting public concern to even threats to national security (Kinchy & Schaffer, 2018). Perhaps the most commonly invoked reason by industries has traditionally been trade secrecy (Kinchy & Schaffer, 2018; Ingre-Khans et al., 2016; Baram, 1984). Businesses claim—more often than not—that providing full access to information about the chemicals they store and handle at their facilities would essentially mean forfeiting their competitive advantage from the technical know-how they have developed over the years. Additionally, disclosing such information could raise public concern resulting to negative impact on nearby property value (McCluskey & Rausser, 2001) or on the regional image and local economy (Slovic et al., 1991). Civic safety can be another reason against information disclosure, because confidential information regarding the presence of hazardous materials can potentially make industrial facilities high-risk targets for acts of terrorism (Schierow, 2013). Moreover, the industrial sector has repeatedly expressed its concerns that sharing too much risk information would cause unnecessary fears and worries among the populace and generate civil unrest (Renn, 1989).

One cannot help but wonder, however, whether information disclosure is an ambition for risk managers or an actual need that originates from within the community. Kapucu (2008) came across a similar question in his study on community hurricane preparedness. He concluded that the views of citizens, who are typically on the receiving end of emergency management services, and the perceptions of emergency managers, who coordinate the risk reduction strategies, might

diverge significantly. Although he chose to focus on the perceptions of county emergency managers for his research purposes, he emphasised the value of appreciating the opinions of other stakeholders, such as local citizens, community leaders, or other public and elected officials, for natural hazard preparedness.

Nevertheless, even though some stakeholders have vigorously resisted to provide open access to chemical information over the years, implementing regulations that obliged industrial facilities to publicly disclose such information has in fact returned positive feedback. A report by the United States Environmental Protection Agency (2000) underscored that risk communication and chemical information disclosure correlated with a substantial reduction in reported risks.

2.1.1 Chemical Risk Information Disclosure Regulation

Risk communication and information disclosure concerning chemical accidents entails public access to appropriate information so that potentially affected communities can be aware of the hazards and risks from nearby hazardous installations, and are prepared to act appropriately in case of an accident (see Guiding Principles for Chemical Accident Prevention, Preparedness and Response; OECD, 2003). As far as the regulatory mechanisms that deal with risk information disclosure are concerned, there are two pieces of legislation that stand out in the global arena; these are the Emergency Planning and Community-Right-to-Know Act (EPCRA; 1986) in the United States (US) and the Seveso Directives (1982/501/EEC, 1996/82/EC, and 2012/18/EU) in the European Union (EU) (Villa et al., 2016). Guidelines for the oversight of technological risks came in part as a response to the overall lack of monitoring standards in the industrial process safety field, and after several highly-publicised, large chemical accidents during the 1970s and 1980s (e.g., Flixborough, UK in '74, Seveso, Italy in '76, Bhopal, India in '84 and Three Mile Island, US in '79) (Villa et al., 2016; Palenchar, 2008).

Section Three of the Superfund Amendments and Reauthorization Act (SARA III), or more commonly known as EPCRA, was passed in 1986. EPCRA obligated chemical companies to fill in and submit reports with data concerning their chemical inventories and their environmental releases, and furthermore make publicly accessible information about the types and quantities of chemicals manufactured, stored, transported and emitted at each industrial site (Palenchar, 2008). Here, it should be mentioned that, even though over 60,000 substances were registered for commercial use in the US at the time, this mandatory information disclosure was limited to only a list of selected extremely hazardous chemicals. Nevertheless, the implementation of the EPCRA created a community right-to-know tool unprecedented for the US chemical regulation arena so far (Wolf, 2018). Overnight, ordinary citizens were able to access critical information about the use and discharge of hazardous materials during the manufacturing processes of nearby industrial

businesses, without any special governmental intervention. The aforementioned mechanism was based on the principles of complete disclosure from industries and the communities' right to access openly information about the presence and release of potentially harmful chemicals from industrial facilities (Wolf, 2018).

The European counterpart regulation had come even earlier than EPCRA; Directive 82/501/EEC was legislated in 1982. Following the tragic industrial accident at Seveso a few years earlier, the framework became known as the Seveso Directive. According to this regulatory framework any industrial facility which involves and/or stores any designated hazardous chemical substance at any point throughout its manufacturing process, was required to draft internal and external contingency and emergency response plans that are based on a risk assessment (Fuentes-Bargues et al., 2017). Additionally, potentially impacted communities were granted the right to be adequately informed concerning the hazardous materials stored at nearby industrial facilities, as well as the potential risks associated with them, and the on-site contingency and emergency response plans in place for dealing with accident scenarios (Renn, 1989). Since the enactment of the initial Seveso standard, over 130 severe accidents took place across Europe, while new types of risks emerged due to technological advancements. Following these developments, the European Commission amended the framework in 1996 through Directive 96/82/EC—later dubbed the Seveso II Directive. These new guidelines categorised industrial facilities into three classes, on the basis of the quantities of hazardous chemical substances present on site: i.e., '*Not Affected*', '*Low Risk*' and '*High Risk*' category. Seveso II was in turn revised in 2012 through Directive 2012/18/EU (or Seveso III Directive). This amendment aimed at expanding the scope of the regulation to incorporate the safeguarding of communities, property and the environment via a more comprehensive framework (Fuentes-Bargues et al., 2017).

Whilst both EPCRA and the Seveso Directives share the overarching goal of reducing chemical accident risks by minimising occurrence probability and mitigating the associated consequences, indeed there is an important difference in the way they approach disaster risk communication. On the one hand, the concept of *community right-to-know* constitutes the cornerstone of EPCRA, as Palenchar (2008) underscores. This straightforward attitude towards risk communication becomes evident even from EPA's (1997, p. 3 in Palenchar, 2008) description: '*Empowering the public with information helps assure [industry] compliance with existing laws and encourages companies to take additional measures to reduce industrial chemical releases*'. On the other hand, Renn (1989) concluded that the primary focus of the Seveso Directive was on risk management and emergency planning. In this sense, risk communication was introduced in the agenda as necessary input to enhance and facilitate risk management, instead of a political or

ethical duty to disclose all critical information with the potentially affected communities. Such a superficial understanding of risk communication for communities is termed '*need-to-know*' and is distinguished from the more comprehensive concept of '*right-to-know*' within risk communication literature (Renn, 1989). Therefore, it may be argued that the goals of both regulatory frameworks are in essence similar concerning risk communication and information disclosure, yet their epistemological origins and approaches seem to be quite different.

As mentioned earlier, EPCRA and the Seveso Directives are generally regarded as two exemplary policy frameworks for risk communication and information disclosure about chemical hazards (Villa et al., 2016). Nonetheless, there are no international standards—let alone a common global framework—on chemical risk information disclosure as of yet. For instance, a technical report by the International Risk Governance Council (IRGC) on maritime critical infrastructure in the South East Asia region, revealed important deficits in the risk governance of high impact events in terms of assessing and understanding risk. One major contributing factor was that governments did not always encourage industries in the maritime sector to publicly share data and information on incidents, even among administrative bodies (IRGC, 2011). In such cases, both government institutions and private companies have been found to err in trying to strike a balance between transparency and confidentiality concerning risk information disclosure. In their defence, government institutions mostly invoked matters of national security, while industrial businesses mentioned concerns for economic liabilities and protecting their reputation (IRGC, 2011).

The global scene of transparency remains quite unclear. Admittedly, access to information may be much easier and widespread nowadays compared to several decades ago, but still we are far from realising a '*truly transparent world*' (Florini, 2007). Among others, economic competition and national security issues tell an even less favourable future for information disclosure from private and public entities alike. Nonetheless, international organisations have unequivocally recognised this issue and try to raise awareness in this direction through their guidelines and publications. A case in point are OECD's (2003) Guiding Principles for Chemical Accident Prevention, Preparedness and Response, which highlight information disclosure and communication with the public as critical elements for the preparedness, mitigation and response concerning chemical accidents. Chemical risk communication is noted in this document as a two-way process in which community participation is key, while the responsibility for communicating with the public is shared among both the public authorities and the industry (OECD, 2003, chap. 7). Keeping up with the research developments at the time, an addendum to the aforementioned Guiding Principles was published later, which specifically addressed Natech accidents. The supplementary Guiding Principles noted that additional information about potential triggering natural hazards should be

communicated to the public along with the chemical accident risk information (OECD, 2015). Another example is the United Nations' Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030, which placed the need to increase the availability of disaster risk information and assessments accessible to the public among its major strategic targets[5] (UNISDR, 2015).

2.1.2 Chemical Risk Communication in Japan and S. Korea

Focusing on aspects pertinent to disaster risk management, Japan and S. Korea share many similarities at first glance concerning their climatological and topographical characteristics, as well as the geographic distribution of chemical industries. Both Japan and S. Korea are frequently affected by natural hazards, such as tropical storms, heavy rains, flooding and landslides, with occasionally significant impact on communities and infrastructure (UNDRR, 2021). One difference, though, is that Japan is located in a highly active seismic zone, and thus is exposed additionally to intense earthquakes more often (Park & Cruz, 2022). Furthermore, Japan and S. Korea have among the largest chemical industries worldwide. Both countries' major industrial parks that include facilities handling hazardous chemicals and oil refineries, are situated mostly along the respective eastern coastlines. It should be noted that in most cases, residential areas have developed around such industrial parks over the years, creating arguably unfavourable conditions considering the exposure of local communities to chemical and Natech accident risk in both countries. Although Japan and S. Korea face apparently similar situations concerning chemical accident risk, they have developed unique perspectives with regard to disaster risk management systems and regulations (Park & Cruz, 2022). It is noteworthy that, while efforts have been made from the authorities in both countries to establish high process safety standards and manage chemical accident overall, specific regulations concerning Natech risk management have yet to be legislated. Bearing this in mind, we proceed by looking into the regulatory framework that governs chemical risk management and communication in Japan and S. Korea.

2.1.2.1 *Japan*

As mentioned previously, due to the lack of a global framework on chemical risk communication and information disclosure, each country develops *ad hoc* legislation to address the subject, naturally with various degrees of effectiveness. Japan's expertise in disaster risk management is world-renowned, especially so in coping with natural hazards. Nonetheless, the picture seems to be different in the field of technological and chemical hazards. Japan's stance on risk communication and chemical risk information disclosure led Ikeda (2014) to conclude that the

[5] The SFDRR (UNISDR, 2015, p. 8) states in particular as one of its seven global targets towards its achievement the following: *'Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030'.*

country seems to lag behind the US and EU in terms of regulatory frameworks[6]. As far as information disclosure about man-made hazards is concerned, the Japanese case bears strong resemblances to the situation of other SE Asian countries; there seems to be a rigid top-down risk governance structure with scarce publicly available information (IRGC, 2011).

The presently active legislation that defines the disaster prevention framework in Japan, the *'Disaster Countermeasures Basic Act'*, makes no reference to technological or chemical risks (Act No. 223, 1961). Apparently, requirements for the industries to report hazardous chemicals inventories and publicly share such data are not included in this act. Furthermore, there is a multitude of laws that relate to disaster prevention concerning industrial complexes with facilities handling hazardous materials in Japan (Krausmann, Cruz, & Salzano, 2017; Cruz & Okada, 2008), the most prominent of which are: the *'High-Pressure Gas Safety Act'* (Act No. 204, 1951), the *'Fire Service Act'* (Act No. 186, 1948), the *'Industrial Safety and Health Act'* (Act No. 57, 1972), the *'Electricity Business Act'* (Act No. 170, 1964), and the *'Act on the Prevention of Disaster in Petroleum Industrial Complexes and Other Petroleum Facilities'* (Act No. 84, 1975). It is noteworthy that only the amended High-Pressure Gas Safety Act explicitly addresses Natech accidents by requiring industrial facilities to take measures to reduce risks from earthquakes and tsunami (Krausmann, Cruz, & Salzano, 2017; Cruz & Okada, 2008). Ishimaru (2020) underscored the apparent regulatory fragmentation and the absence of a cross-sectoral governing institution within the Japanese legislative framework for the risk management of major chemical accidents at industrial complexes. Furthermore, the aforementioned regulations prioritise industrial process safety setting admittedly high standards, yet they do not include any provisions about chemical risk information disclosure, let alone define a risk communication strategy with the broader public.

The only regulatory article that explicitly requires industrial facilities to publicly disclose information regarding dangerous substances is found within the Law for *'Pollutant Release and Transfer Register Law and Promotion of Chemical Management'* adopted in 1999 (Act No. 86, 1999a). The Pollutant Release and Transfer Register (PRTR) system dictates that businesses which handle chemicals potentially harmful to the environment are obligated to estimate the volume of such releases, and report the data to the local governments. In turn, the national administration compiles this information and publishes the aggregated results to the citizens on a yearly basis[7] (Act No. 86, 1999a). However, the principal issue this regulation addresses is not that of technological accident risks. Instead, it aims at monitoring the environmental discharge levels of

[6] Ikeda (2014, 632) noted: *'we were far behind the US and EU countries in starting regulatory reform from the paternalistic top-down to the informed choice on risk under proper institutional setting in Japan'.*

[7] Japanese PRTR data is available from the website of the Ministry of Environment, Government of Japan (https://www.env.go.jp/en/chemi/prtr/prtr.html).

specific chemical substances to the environment. Undoubtedly, the system delineates the foundations for risk communication between the government, the industries and the citizens, but the main goal is to foster voluntary improvement of industries for the management and reduction of environmental pressures from the usage of toxic chemical substances. In other words, the preservation of the environment is the top priority. It becomes apparent that the framework does not apply to future scenarios that involve releases of hazardous materials caused by technological or Natech accidents with potentially severe consequences to the local community and/or the environment.

Rather unsurprisingly, considering the aftermath from the Great East Japan Earthquake and Tsunami (GEJET), special provisions targeted at promoting transparency of the decision-making processes concerning nuclear disaster management were introduced. Relevant laws such as the *'Atomic Energy Basic Act'* (Act No. 186, 1955) and the *'Act on Special Measures Concerning Nuclear Emergency Preparedness'* (Act No. 156, 1999b) were amended in an attempt to restructure the Japanese nuclear disaster management framework. As stated in the White Paper on Disaster Risk Management 2015 (Disaster Management Bureau, Cabinet Office, Government of Japan, 2015), a Nuclear Regulation Authority (NRA) was created based on lessons learned from the Fukushima accident with the mission to ensure the reliability of monitoring authorities so as to foster public trust. Thoroughly disclosing regulatory information pertaining to the related decision-making processes is within its scope of actions. This regulatory body is still active and regularly holds public hearings (Disaster Management Bureau, Cabinet Office, Government of Japan, 2018). Understandably so, this publicly shared information is related to nuclear disaster management and does not apply to the case of facilities handling hazardous chemical substances.

In sum, contrary to the modern age of proliferating communication and ease of access to information, there seems to be little to no information disclosure concerning chemical—and by extension Natech—accident risk in Japan. Notable efforts have been made from the government side to address this issue concerning nuclear disaster management, and perhaps they achieved it to a certain degree, yet the question remains for chemical accident risk. Scholars who looked into the developments of risk communication in Japan in the post-Fukushima era noted that this scarcity of publicly available chemical risk information has resulted in little preparedness from a citizens' standpoint to address low probability, but high impact technological accidents (Ikeda, 2014; Kinoshita, 2014; Hasegawa, 2013; Figueroa, 2013). Moreover, a recent study which examined risk perceptions and evacuation behaviours at household level following the Fukushima accident, also highlighted the challenges for community preparedness against accidents given the overall lack of publicly available chemical risk information to local residents (Yu, Cruz, & Hokugo, 2017).

2.1.2.2 *South Korea*

The basic structure of the regulatory system governing chemical risk management in S. Korea is similar to the Japanese case described earlier. The Korean government has passed a number of regulations that govern different aspects related to chemical process safety and the handling of hazardous materials, based on the scope of their relevant agencies (Lee & Choi, 2015). These include *'High-Pressure Gas Safety Control Act'* (Act No. 2494, 1973), the *'Occupational Safety and Health Act'* (Act No. 3532, 1981), the *'Framework Act on Fire Services'* (Act No. 6893, 2003a), the *'Marine Environment Management Act'* (Act No. 8371, 2007), and the *'Act on the Safety Control of Hazardous Substances'* (Act No. 6896, 2003b). Following the GEJET, S. Korea revised its nuclear disaster management regulation by introducing stricter safety standards through the *'Nuclear Safety Act'* (Act No. 10911, 2011). All the above regulations include among their objectives the management and reduction of industrial accident risk from various types of hazardous materials (Park & Cruz, 2022; Lee & Choi, 2015).

September 27, 2012 marked an important incident in the Korean history of chemical risk management, which subsequently affected the direction of its related legislation. A chemical accident attributed to human error led to the release of approximately eight tons of toxic hydrogen fluoride (HF) gas from a facility at the national industrial complex in Gumi. This accident resulted into the death of 23 individuals living and working nearby, and the hospitalisation of more than 12,000, on top of the serious environmental and economic impact (Park & Cruz, 2022; Lee et al., 2018). Jung and Park (2016) examined the incident looking particularly into the inter-organisational information exchange networks during the crisis management phase, revealing certain shortcomings of the Korean emergency response system for chemical accidents. In short, they noted (i) the absence of a two-way risk communication strategy between emergency response authorities; (ii) lack of staff with specialised know-how; (iii) insufficient appropriate and up-to-date information; and (iv) overall little operational preparedness for major chemical accidents (Jung & Park, 2016). This tragic incident demonstrated to Koreans first-hand that such chemical accidents, although rare, can have detrimental consequences over large areas, affecting the surrounding communities and environment (Lee et al., 2018). This served as an incentive for the Korean government to review its laws and regulations pertaining to risk management of chemical accidents in order to better protect its citizens. Thus, through the consolidation of fragmented past laws on the control of toxic chemicals and in consideration of the contemporary needs, the *'Chemical Substances Control Act'* (Act No. 12490, 2014) was ratified in 2014.

The *'Chemical Substances Control Act'* defines a disaster risk management framework for all industrial companies that handle hazardous materials and conduct business in S. Korea. Its

overarching purpose is civic and environmental safety from chemicals through management and prompt response to potential accidents (Act No. 12490, 2014). Industrial companies that handle chemicals requiring preparation for accidents according to this legislation, bear the responsibility of drafting and submitting a *Hazard Control Program*, which is to be updated at least once every five years. This Hazard Control Program is essentially a comprehensive chemical accident risk management plan. It is based on a wide-area consequence analysis considering not only the impact on the facilities themselves, but also the effects on nearby communities and surrounding environment (Act No. 14532, 2018, article 23).

Particularly with its later amendment in 2017, the law introduced chemical risk communication together with requirements for risk information disclosure to nearby communities. For example, article 42 states (Act No. 14532, 2018): *'Any person who handles chemicals requiring preparation for accidents shall give notice […] of a risk management plan in an easily understandable form to local residents […] at least once a year'*. More importantly, apart from submitting the aforementioned Hazard Control Program to responsible authorities, the facility operator is obliged to take appropriate measures to adequately inform local communities about it—including any modifications to the plan—at least on a yearly basis. This entails, sharing information proactively in writing (e.g., pamphlets) or through individual explanation (e.g., door-to-door meetings) or during local community meetings to all potentially affected population. Information to be disclosed concerns (i) hazard information related to the potential chemical accident risk and to the hazardous chemicals handled in the facility; (ii) the estimated scale of the impact on air/water/soil quality, and the natural environment in case of a chemical accident; and (iii) the methods via which early warnings and instructions for protective action will be transmitted to residents in case of an accident (Act No. 14532, 2018, article 42). Moreover, additionally to the proactive information sharing described above, the law stipulates that facility managers must comply and respond to any individual requests for information disclosure by potentially affected residents.

Governmental agencies also assume certain responsibilities concerning information disclosure based on this regulatory framework. State and local governments need to mobilise their resources to formulate and implement measures necessary to prevent risks posed by chemicals to human health and the environment. Among other tasks, they need to include activities for education and public relations about managing chemicals (Act No. 14532, 2018, article 4). The Ministry of Environment, as the chief regulator, will carry out regularly statistical surveys on the current status of hazardous chemicals and how they are handled by the respective facilities. These results are to be made publicly available through a 'Comprehensive Chemical Information' platform established and operated by the Ministry of Environment (Act No. 14532, 2018, article 48). Of

course, it should be noted that there are certain unavoidable caveats regarding information disclosure, where information may be withheld from the public by government authorities if deemed detrimental for public order maintenance, public welfare, national security, or due to trade secret issues.

It becomes apparent that S. Korea has taken some significant steps towards, strengthening its regulatory framework with the aim of reducing risks from potential chemical accidents and protecting citizens. Another notable example was the establishment of the Joint Inter-agency Chemical Emergency Preparedness Centres (JCEPCs) at each of the seven national industrial complexes since 2018. These entities are tasked with activities related to risk management, preparedness for effective response and civic safety, crisis management and recovery support. However, despite such significant strides, there is room for further improvement, as researchers noted (Lee et al., 2018; Jung & Park, 2016). The Chemical Substances Control Act has been criticised for prioritising the safety of workers from exposure to hazardous chemicals over the protection of nearby citizens from large-scale accidents (Han & Park, 2018). Han and Park (2018) examined the levels of risk awareness of residents living near chemical industrial complexes. Their survey results demonstrated that there is a need for the Korean chemical disaster management framework to place further emphasis on risk communication, reiterating the importance of community engagement and multi-stakeholder cooperation in effectively reducing chemical accident risks (Han & Park, 2018). From our perspective, we should mention here that Natech accidents and their inherent complexities have yet to be explicitly addressed in the currently active Korean legislation system.

2.1.3 Right-to-know and Participatory Risk Management

2.1.3.1 Right-to-know

Mol (2006) argued that we currently live in an *'Information Age'* that has profoundly influenced our governance structures. Characteristic of this era is that *'regulation by revelation'* (Florini, 1998) and *'governance by disclosure'* (Gupta, 2008) have become the norm and are in fact preferred compared to other command-and-control-type of regulatory approaches by government institutions. Indeed, policymakers, researchers and activists increasingly promote transparency as the way to oversee and effectively reduce environmental and health risks associated with major industries (Kinchy & Schaffer, 2018; Gupta & Mason, 2014). The *'right-to-know'* (see Hadden, 1989; Baram, 1984) lies at the heart of this contemporary governance approach, and it has been expanding and evolving as a policy concept over the years (Kinchy & Schaffer, 2018; Florini, 2007). Originally, it was based on the mantra that *'sunlight is the best disinfectant'*, which largely guided the introduction of transparency policies involving the public

disclosure of government documents during the '60s and '70s in the US and other western countries (Kinchy & Schaffer, 2018). Later, a 'second wave' of '*targeted transparency*' regulations defined governance structures in the '90s, whereby government and business institutions adopted public information disclosure as an alternative way to regulate environmental and health issues (Fung, Graham, & Weil, 2007). Such targeted transparency policies, for instance enhancing public engagement in decision-making about potentially hazardous technologies, were aimed at reducing health, financial and safety risks, minimising corruption, protecting civil rights and improving public services (Kinchy & Schaffer, 2018; Fung, Graham, & Weil, 2007). Needless to say, the concept of right-to-know has significant implications for disaster risk management, too, as discussed next.

Citizens who live nearby or work at potentially hazardous industrial plants are neither avaricious nor misguided in their basic reasons and desires to be safe. Individuals seem to be inherently sensitive to the equality of risk distribution vis-à-vis others members of the community as well as the environment (Palenchar & Heath, 2007). Singer and Endreny (1987) posit that these are a few of the key motivators individuals employ in the cognitive process of deciding whether a presented problem affects them to a degree it justifies their attention, either through taking personal action or by seeking a collaborative solution. Mileti and Peek (2000) explained that information about a threat and suggested protective measures against it acts as dominant stimuli to engage in the process of forming perceptions about the presented risk. In the context of technological risk management, the essential input for this cognitive process, based upon which an individual can judge the situation in terms of the involved level of threat and the fairness of its distribution, is risk information. However, access to such information becomes a challenging discussion topic, considering that more often than not stakeholders have different interpretations or conflicting interests.

The discourse about the citizens' '*right-to-know*' and the governments' and industries' '*duty-to-disclose*' *per se* has been on-going for decades (Baram, 1984). Even though there are many approaches to the concept of right-to-know, Hadden (1989 cited in Palenchar, 2008) distinguished four main levels: (i) an individuals' basic right to know the situation they are in; (ii) the right to know to take measures to reduce the risk; (iii) the right to know so as to participate in the decision-making processes; and (iv) the right to know in order to change the power balance. In this vein, the notion represents a linear continuum of '*rights-to-know*', while these four levels mark the transition points, which are not entirely alien to each other. Risk communication researchers agree on the importance of right-to-know, emphasising its fundamental role in empowering communities to openly discuss about risks with government and businesses on equal grounds (Palenchar, 2008).

Moreover, the amount and quality of information builds and enhances the capacity to actively engage in risk management and environmental monitoring (Palenchar, 2008).

Communicating risk is a fundamental principle for care promotion in terms of community preparedness aiming at risk reduction, but also for consensus-building pertaining to its management (Lundgren & McMakin, 2013). Organisations responsible for this communication need to inform communities of any potential consequences their activities might have so as to ensure that all stakeholders—and especially citizens—are prepared for a chemical release accident. As far as individuals are concerned, the merits of information disclosure include appropriate evacuation plans and risk-informed decisions. However, this right-to-know does not apply exclusively to citizens. Additionally, the emergency response mechanism can benefit greatly by the disclosure of vital chemical risk information prior to an incident. For example, emergency response teams can plan ahead and allocate more efficiently available resources and staff or arrange for special training and equipment in order to be able to respond more swiftly and effectively during a chemical accident. Understandably, the challenges grow exponentially when considering large-scale and complex disasters, such as chemical and Natech accidents. After the initial hazardous event, potential chemical releases pose another threat to emergency respond teams and evacuees in the area, whilst complicating even further the safe return process (Yu, Cruz, & Hokugo, 2017).

But addressing the issue of citizens' right-to-know about the risk they are subject to is only one step towards the goal of encouraging public participation in disaster risk management, as elaborated through Hadden's approach (Palenchar, 2008). Community engagement in risk-related decision-making processes, despite being strongly advocated for in academic literature, still remains elusive in reality (Samaddar et al., 2017; Pandey & Okazaki, 2005). Risk managers have been criticised for employing central, top-down approaches to disaster risk reduction, which generally disregard local and social specificities and effectively shut down communities from actively participating (Pandey & Okazaki, 2005; Burby, Steinberg, & Basolo, 2003). On the other hand, communities tend to—erroneously—rest assured on the idea that drafting and implementing risk reduction strategies is exclusively a government duty (Basolo et al., 2009), and therefore do not vigorously pursue their role in maintaining and improving civic safety vis-à-vis disaster risk.

Recently, emphasis is placed by many disaster risk reduction practitioners and scholars, especially social scientists, on bottom–up approaches, which encourage risk communication to be undertaken throughout policymaking in order to foster more participatory methods in risk management (Fekete, 2012). Transparency and dissemination of risk information have been widely recognised as essential elements in cultivating a milieu of trust between institutions and communities, and go a long way towards fostering participation in risk reduction processes

(Figueroa, 2013; Pandey & Okazaki, 2005; Burby, Steinberg, & Basolo, 2003; Maeda & Miyahara, 2003). Actors from all backgrounds are urged to engage in the risk-related decision-making processes. Moreover, risk communication and open access to related information is important from an ethical practice standpoint, as it fosters accountability of involved stakeholders and allows risk-informed decision-making (Sellnow et al., 2009). The views of citizens, social groups, businesses and institutions are equally valuable in deciding collaboratively suitable ways of coping with risk (Figueroa, 2013; Klinke & Renn, 2010; Pandey & Okazaki, 2005). But the strongest argument for strategic risk communication throughout the disaster risk management processes is *co-designing* the discussion framework (Figueroa, 2013; Klinke & Renn, 2010). Klinke and Renn (2010, p. 24) pointed out that *'it is not the task of the communicators to decide what people need to know but to respond to the questions of what people want to know'*. Hence, risk managers should pay due attention to the concerns and perceptions of the communities.

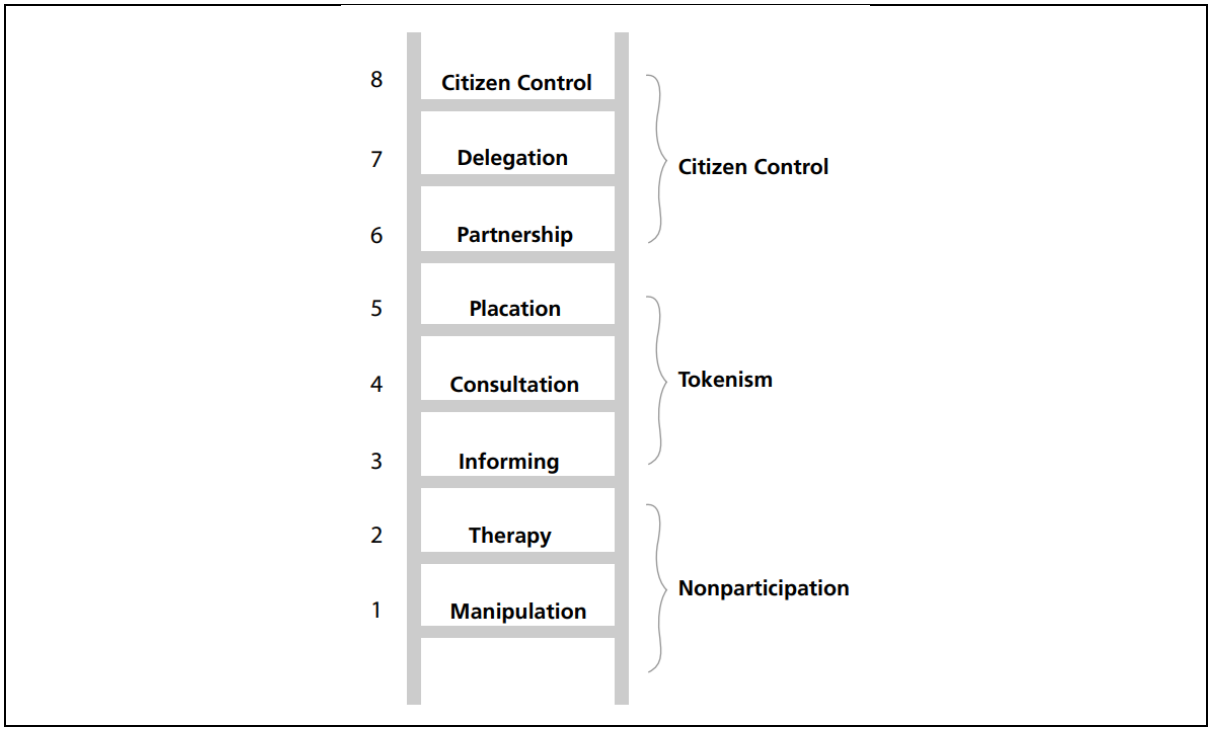
2.1.3.2 *Participatory Risk Management*

Elaborating on the subject of participatory disaster risk management, research has shown that community response to disasters varies depending on the types of hazards and regional characteristics of the respective disaster management system they are embedded in (Paterson & Charles, 2019). Proactive and meaningful participation from community members is essential for disaster preparedness and response activities (Witvorapong, Muttarak, & Pothisiri, 2015). Witvorapong et al. (2015) investigated the contribution of social capital and community involvement in disaster mitigation activities for earthquake and tsunami preparedness in Thailand, and demonstrated their importance for disaster risk reduction at the local level. This *'social capital'* refers to *'social participation'* in community activities, such as membership in volunteering, religious, or other types of associations, and can be seen as a local resource inherent to the community or even as an individual attribute (Chola & Alaba, 2013; Hyyppä & Mäki, 2003). Social participation encourages individual community members to interact with each other, creates social networks to share information, and fosters a milieu of trust among group members (Witvorapong, Muttarak, & Pothisiri, 2015). Community participation in disaster risk management at the local level is widely regarded as a critical component for the enhancement of community resilience (Zubir & Amirrol, 2011).

Scholars have approached public participation from many perspectives. One of the most influential approaches is Arnstein's (1969) proposed *'ladder of citizen participation',* in which she contemplated citizen participation with regard to *'citizen control'* and the *'feasible involvement'* of the community. This framework is recognized by many as the 'cornerstone of democracy' (Lasker & Guidry, 2009) and discusses in detail the functions of participation. This conceptual ladder (Figure

2.1-1) describes an intentionally provocative typology of citizen participation with a total of eight levels of community involvement in the planning process. These levels are divided into three stages: (i) *'non-participation'*, which includes *'manipulation'* and *'therapy'*; (ii) *'Tokenism'*, which includes *'informing'*, *'consultation'* and *'placation'*; and (iii) *'citizen power'*, which involves the levels of *'partnership'*, *'delegation'* and *'citizen control'*. The higher the level of citizen control over the decision-making process, the greater the level of meaningful community participation (Arnstein, 1969). This framework has been extensively employed in the academic areas of urban planning, public and health policy, and sociology (see Lasker & Guidry, 2009) and in the disaster risk management field (e.g. see MacAskill, 2019; Samaddar et al., 2017).

Figure 2.1-1 Arnstein's Ladder: Degrees of Citizen Participation



Source: Arnstein (1969) (available at: https://www.citizenshandbook.org/arnsteinsladder.html [Accessed 3 April, 2021])

Subsequent work has expanded upon this theoretical framework. Hurlbert and Gupta (2015), for instance, proposed the *'split ladder of participation'* taking into consideration the uncertainty involved in policy decisions and trust-building as a catalyst for citizen participation. By analysing the effectiveness of public participation under various conditions throughout the decision-making process, the researchers noted that citizen engagement diminishes as we move from unstructured problems to more structured problems (Hurlbert & Gupta, 2015). Typically, unstructured problems (e.g., climate change) are associated with increased social concern, controversy and uncertainty, and require deep social learning through citizen participation (Hoppe,

2010). On the other hand, structured policy problems can be dealt with in a more technocratic manner requiring minimal public participation (Hurlbert & Gupta, 2015).

Other theoretical frameworks of community participation and engagement have been developed, in part to overcome the criticisms about the ladder's linearity (Wondolleck, Manring, & Crowfoot, 1996), as well as to incorporate other less explored aspects (Ross, Baldwin, & Carter, 2016; Ross, Buchy, & Proctor, 2002). Significant works include Davidson's (1998) *'wheel of empowerment'* which also inspired an ongoing discussion. This framework offers a practical guide to involving the public in decision-making process, describing four key stages: initiation, internal capacity-building, external capacity-building, and engagement. The circular depiction emphasises the iterative and continuous efforts required to maintain social dialogue (Davidson, 1998). Even international organisations weighed in the discussion, offering their models for citizen participation. The preeminent international organisation in the field, the International Association of Public Participation (IAP2) developed the *'Spectrum of Public Participation'* to *'assist with the selection of the level of participation that defines the public's role in any community engagement program'* (IAP2, 2014). It is comprised of five participation levels that progressively increase citizens' impact on the decision: (i) *'inform'*, (ii) *'consult'*, (iii) *'involve'*, (iv) *'collaborate'*, (v) and *'empower'*.

Despite the academic discourse and the various participation models that have been developed over the years, significant challenges for public engagement in disaster risk management have not been effectively addressed. Scholars have stressed that inadequate levels of trust and poor communication with experts or governmental agencies can be detrimental for community participation (Gaillard & Mercer, 2013; Owens, 2000), but also that active community engagement in disaster risk management can serve as a means to (re-)build trust relations with the government organisations (Wells et al., 2013). Additionally, Godschalk et al. (2003) found that low public interest can have a negative impact on community participation concerning hazard planning. On the other hand, there are issues associated with excessive effort from stakeholders to involve the public in the risk management process. Indeed, Gaillard and Mercer (2013) highlighted that widespread *'participation fatigue'* may decrease citizen's motivation to participate in risk reduction decision-making, as it has been found to lower public interest in the matter and widen the understanding gap between experts and citizens.

Several studies tried to identify factors contributing to active community engagement in disaster risk management, including decision-making during emergencies. MacAskill (2019) examined community participation during the disaster recovery phase and highlighted the importance of local human and financial resources, changing public perceptions about what community engagement in disaster risk management entails for citizens, as well as building trust

towards the government decisions. Other scholars highlighted the significance of leadership, strategic partnerships, comprehensive initiatives for public dialogue, efficient governance structures to enable local-level engagement, and suitable risk communication among relevant stakeholders in promoting public participation in disaster risk reduction (Burnside-Lawry & Carvalho, 2015). Mat Said et al. (2011) investigated tsunami risk management in Malaysia and concluded that empowerment is a critical component for risk-related decision-making concerning the allocation and utilisation of available resources. Moreover, bearing in mind that community-based risk management requires coordination and cooperation from all involved actors, risk governance structures need to be revaluated to avoid stifling bottom-up initiatives with rigid top-down approaches (Mat Said et al., 2011).

Through analysing the social and political capacities of communities in response to major flooding events in Canada and Australia, McMartin et al. (2018) indicated that enhanced risk communication and capacity-building activities, alongside a comprehensive empowerment model can offer avenues for identifying and tackling community vulnerabilities to extreme flood and drought hazards. Zubir and Amirrol (2011) noted that sharing local knowledge and expertise, such as community experiences, and setting regionally embedded disaster management systems and coordinated community-based governance structures, can go a long way towards enhancing citizen participation in disaster risk reduction processes. Studies in middle eastern countries also pointed out the contribution of raising public risk awareness, enhancing capacities (such as local knowledge and skills), and developing an enabling governance environment in positively influencing public involvement (Valibeigi et al., 2019; Enshassi, Shakalaih, & AlKilani, 2019). Berkes and Ross (2013) examined community resilience from the perspectives of social–ecological systems and the psychology of development and mental health. Their findings suggested fostering adaptive relationships, knowledge-sharing and learning across nested governance levels and further enhancing community resilience through agency and self-organisation, with due consideration to people–place connections, values and beliefs, social networks, collaborative governance and economic diversification (Berkes & Ross, 2013). In this vein, Allen (2006) stressed the significance of acknowledging and respecting local sociocultural characteristics vis-à-vis community-based disaster risk management approaches. Since local communities are embedded in different social and physical environments, they naturally develop different coping mechanisms and capacities, including disaster risk perceptions, regional resources and engagement systems (Allen, 2006). It is therefore, imperative that we do not treat community-based disaster risk management as a panacea adopting 'one-size-fits-all' methods with hopes of resolving any issue. In sum, certain key influential factors for community engagement in risk reduction emerge from

the academic literature. These include enhancing systemic risk governance at the regional level, meaningful risk communication among all stakeholders, promoting a sense of community, and incorporating existing social capital, indigenous knowledge and experiences.

2.1.4 Previous Research

Considering the virtues and furthermore the challenges involved in promoting participatory disaster risk processes, much of the academic discourse has been devoted in understanding the lay audience's cognitive beliefs and risk perceptions as influencing factors of risk communication (Wachinger et al., 2013; Slovic, 2000). Even so, only a small portion of the literature touches upon the subject of risk communication from the perspective of community right to demand public disclosure of chemical information.

On the one hand, there are scholars who advocate for reducing the information gap for chemical risk by effectively addressing the '*demand*' through regulatory action (Applegate, 2008). Palenchar (2008) carried out an ethnographic case study, attempting to shed some light on residents' perceptions and level of awareness regarding federally mandated right-to-know initiatives in the US. His observations were quite revealing; he demonstrated a generalised absence of awareness and basic understanding of community right-to-know initiatives from the residents' standpoint. These findings go a long way to show that residents are far from making any claims on their right to be informed about the chemical risks they are subject to, despite the appropriate regulation being in place to allow them to do so. In any case, Palenchar (2008) recognised that additional research from a variety of disciplines is required in order to appreciate the role of community right-to-know in risk communication.

It is noteworthy that the emerging area of social research on fracking[8] has investigated issues pertaining to chemical risk information disclosure (Kinchy & Schaffer, 2018). Studies have demonstrated that chemical information disclosure plays in important role in how the public perceives the petroleum extraction industry (Mazur, 2016; Evensen, Clarke, & Stedman, 2014; Maule et al., 2013). Also sharing information allows the responsible authorities and involved stakeholders to better prepare against the associated health and environmental hazards (Maule et al., 2013). Additionally, transparency has been acknowledged as a new way of governance concerning environmental issues (Mol, 2010; Gupta, 2008; Fung, Graham, & Weil, 2007).

A few researchers examined risk communication and participatory risk management approaches in Japan focusing on chemical and Natech accident risk. Not surprisingly, risk

[8] *'Hydraulic fracturing'* or *'fracking'* is defined as the injection of fluid into shale beds at high pressure in order to free up petroleum resources (such as oil or natural gas). It is employed in the in natural gas and petroleum extraction industry.

communication practices surrounding the Fukushima nuclear accident monopolise the scientific interest. Figueroa (2013) approached the topic through the prism of anthropological research. As far as risk communication practices are concerned, he stressed the lack of transparency in the decision-making processes from an administrative perspective. Along the same lines, participatory risk management initiatives, where policymakers, stakeholders and local community representatives can cooperatively discuss and build consensus about risk-related issues were inadequate. Taking as an example the way public hearings discussing nuclear power plant construction have been conducted in Japan, Figueroa (2013) concluded that public participation remained a formality rather than an opportunity for substantial dialogue between communities and regulators. Following our previous discussion, we would argue that issue conflicts with the communities' claims for their right-to-know.

More recently, Murakami and Tsubokura (2017) discussed the influences and justifications of risk communication, and how risk communication systems are designed in the post-accident Fukushima era. Their nudge theory approach discovered rather '*ethically unjustifiable*' risk communication practices that should revaluate the relationship between citizens and the government. Apart from the characteristically scant government efforts for risk communication pertaining to chemical accident hazard in Japan (Yu, Cruz, & Hokugo, 2017), a household survey by Yu and Cruz (2016) also revealed that residents felt that there were no community initiatives to disseminate information and prepare for chemical or Natech accidents. Another impediment in participatory methods is the communities' relatively low level of trust in the government's ability to protect them from potential chemical accidents (Yu & Cruz, 2016).

Furthermore, Kumasaki and King (2020) studied three recent Natech events in Japan and emphasised once again the need to provide up-to-date risk information about the situation to all stakeholders and potentially affected communities. Similarly, literature reviews looking at lessons learned from the Fukushima nuclear disaster concerning radiological risk communication in Japan, highlighted the need to promote risk communication prior to an accident in order to enhance community preparedness (Takamura et al., 2021; Yamaguchi et al., 2018; Perko, 2016). Takamura et al. (2021) in particular, noted the crucial function of cognitively and psychologically priming the public through disaster education and emergency drills to assist them in receiving, processing and responding to information during the critical hours of the event. From a risk governance perspective, however, it should be mentioned that community involvement was only mentioned within the context of taking part in disaster preparedness activities and information seminars, rather than participation in a broader public discourse about nuclear risk management.

In contrast to the Japanese situation, scholars have only recently started investigating the Korean disaster risk communication scene with regard to chemical accidents, and thus there are only a few studies currently available[9]. Afterall, the change in the regulatory framework through the *'Chemical Substances Control Act'* (Act No. 14532, 2018) is still quite recent. As mentioned in a previous section, while the enactment of the Chemical Substances Control Act is generally regarded as a positive step for chemical risk management and risk communication, it has also received its fair share of criticism (Lee et al., 2018). Han and Park (2018) commented about the chemical risk communication setting in S. Korea that the current legislation seems to focus excessively on the safety of industrial workers. In reality, citizens rarely receive any accurate information in the case of chemical accidents, often on the grounds of maintaining public order, despite the provisions incorporated in the law (Han & Park, 2018).

Overall, academics delineated a picture of no meaningful public participation in technological risk management in Japan (Shimizu, 2016; Mochizuki, 2014). In terms of chemical and Natech accident risk, communities seem to be mainly—or just—passive receptors of the little risk information made publicly available. Nevertheless, other researchers noted a surge in citizen activism recently, and suggested that this situation might be gradually changing, as communities have been proactively seeking out opportunities to become involved in risk-related policymaking ever since the Fukushima accident (Figueroa, 2013). For S. Korea, although a comprehensive regulatory framework has been enacted, researchers have their reservations about how it is interpreted and implemented by facility managers in reality.

In summary, based on the literature review presented here, we observed the following two important points while exploring Natech risk communication. First, the topics of Natech risk perception and communication have only just begun to emerge in the academic discourse. Within this young body of literature there are still no studies that investigate citizens' views about Natech risk information disclosure. In this regard, the issue of citizens' demand or 'appetite' for chemical and Natech risk information deserves more attention from risk communicators and risk managers alike and warrants further study. Second, from an academic and practical standpoint, it is important to explore methods for introducing Natech risk communication and chemical information disclosure to the public. However, as discussed earlier, risk communication is not only a matter of publicly sharing accurate and understandable hazard information, but also entails co-designing the risk management framework along with all involved stakeholders. Thus, it is equally important to propose tools to actively engage communities in the Natech risk management

[9] It is probable that the academic literature on the subject is not limited to the short discussion presented here, but due to language barriers, articles written in English were only included here.

process. Therefore, the following questions remain unanswered still. ***What are the effects of pursuing chemical accident risk communication in citizens' communicative behaviour and their relations with involved organisations concerning the issue of Natech risk information disclosure? How can we promote Natech risk awareness and stimulate stakeholder engagement in disaster risk management?***

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Chapter 3 Investigating Citizens' Communicative Behaviour for Natech Risk Information Disclosure: A Comparative Study between Japan and S. Korea

3.1 Introduction

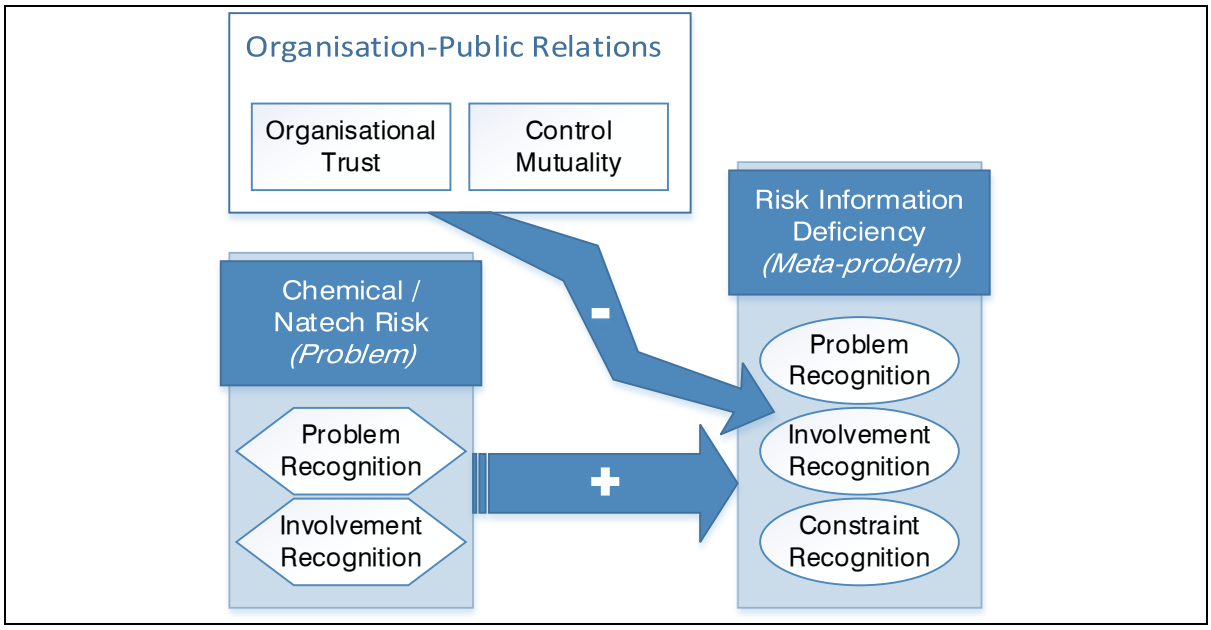
Active community involvement in disaster risk management is widely acknowledged as one of the key factors for effective disaster risk reduction. Nevertheless, engaging communities in disaster risk management processes has proven to be easier claimed than realised in most cases. Despite continuous and extensive efforts from international organisations, such as the United Nations, to develop sustainable programmes for disaster-resilient societies, community-based disaster management schemes are still not the norm (Samaddar et al., 2017; Pandey & Okazaki, 2005). In most cases, disaster risk management involves 'top-down' approaches planned and implemented by central government, often overlooking any spatial and social specificities that would otherwise require special attention (Burby, Steinberg, & Basolo, 2003). On the other hand, communities themselves tend to perceive disaster risk management as a government responsibility (Basolo et al., 2009) and, thus, often opt to remain passive receptors. In order to resolve this situation and actively engage local communities in disaster risk management, the entire narrative needs to be revaluated, so as to 'open' the decision-making processes to the public.

There seems to be a general consensus among academics and practitioners alike that transparency and dissemination of information create favourable conditions for sustainable community-based disaster risk management since they encourage trust-building and participation (van Asselt & Renn, 2011; Aven & Renn, 2010; Pandey & Okazaki, 2005). By extending such processes to citizens and adequately informing them about the latent risks, communities can better prepare in order to cope with such scenarios. Community right-to-know initiatives lie in the heart of this empowering participatory disaster risk management approach by setting the conditions for relationship-building through a continuous, civic dialogue among stakeholders (Palenchar, 2008; Palenchar & Heath, 2007).

Remarkably, some of the most vulnerable people to natural or man-made disasters are the ones less prepared for the risks they are subject to due to limited access to sources of key disaster information (Hansson et al., 2020). Thus, risk communication and community involvement in disaster risk reduction processes gain specific importance when facing large-scale, complex disasters that combine the two types of hazards, such as Natech accidents. Natech accidents are defined as technological accidents caused by a natural hazard that involve the accidental release of hazardous substances (UNDRR-APSTAAG, 2020). Representative examples include the fires and

explosions at a major oil refinery following the Great East Japan Earthquake and Tsunami (GEJET) in 2011 (Krausmann & Cruz, 2013) and the accidental hazardous material releases triggered by Hurricanes Katrina and Rita (Cruz & Krausmann, 2009) introduced in Chapter 1. Although not frequent, such events pose a great challenge for disaster risk managers because of their severe impact, causing enormous economic losses and long-lasting effects on human health and the environment (Luo, Cruz, & Tzioutzios, 2020; Krausmann, Cruz, & Salzano, 2017; Masys et al., 2014).

Figure 3.1-1 Conceptualisation of the meta-problem of Natech risk information deficiency



Source: Original work

The argument for zero-risk conditions concerning chemical and Natech accidents can be easily refuted as impossible in the disaster risk management discipline (Hansson, 2005), regardless of the expended risk reduction efforts from involved organisations. Bearing this in mind, we would argue that a primary 'problem' for potentially affected communities arises from the chemical/ Natech risk itself they are exposed to (see Figure 3.1-1). If communities do not have access to enough risk information in order to prepare against a potential chemical/Natech accident and participate in the risk-related decision-making, they may start to perceive a related '*meta-problem*' of risk information deficiency. Since the primary problem cannot be completely resolved and therefore persists, the meta-problem is perpetuated. Actually, depending on the perceived severity of the risk, communities' perceptions and concerns regarding the lack of risk information may be accentuated.

However, the effectiveness of disaster risk management organisations can be enhanced via cultivating a favourable and collaborative climate with strategic risk communication audiences (Grunig, Dozier, & Grunig, 2002). In this regard, investing in trust (organisational trust) and shared

decision-making power (control mutuality), community concerns vis-à-vis the meta-problem of risk information deficiency can be addressed. Expanding on this idea, by pursuing risk communication to comprehensively and effectively address the issue of Natech accident risk, not only yields the immediate benefits of improving community preparedness against such disasters through publicly disclosing critical risk information, but additionally improves the cooperation relations among stakeholders overall. In turn, this can help moderate the perceived meta-problem of information deficiency. Ultimately, the secondary negative effects that derive from the inherent inability to completely address the initial risk can be mitigated. By bringing closer the government, businesses and the public for discussion, perceived problems and barriers pertaining to the residual disaster risk can be diminished, whilst achieving a mutual understanding over each other's viewpoints ensures risk-informed, democratic and legitimate decisions (Aven & Renn, 2010).

Centring on this meta-problem of information deficiency, this study ventures to explore: *What are the differences in the communicative behaviours of citizens in Japan and S. Korea concerning the issue of Natech risk information disclosure?* Through the cross-national comparison of two relatively similar countries in terms of organisational culture (see e.g., Hofstede, Hofstede, & Minkov, 2010; House et al., 2004; Hofstede, 2001), we attempt to capture any underlying institutional factors that may influence citizens' perceptions and motivation to communicate about the issue. To the best of our knowledge, this is the first cross-national comparative study in the field of Natech risk communication. It also contributes to the limited literature on risk perception and communication focusing on cross-national comparisons among Asian countries. Moreover, this study is a novel, yet elementary, try to examine the previously explained narrative and understand how organisation-public relations can affect citizens' communicative behaviour concerning the issue of Natech risk information disclosure.

Approaches traditionally employed in the domain of public relations and mass communication can be particularly helpful in shedding some light onto what is the public's perceptions about the issue at hand. The *Situational Theory of Problem Solving (STOPS)*, proposed by Kim and Grunig (2011), can help researchers evaluate the level of community 'appetite' for Natech risk information disclosure and risk communication, as well as to understand the communicative behaviour patterns and perceived challenges of different audiences. Thus, our study contributes to the disaster risk communication literature by applying the STOPS framework in the context of pre-event risk communication for preparedness, specifically looking at the communicative behaviour of individuals before an actual chemical accident takes place to inform research and practices at the preparedness stage. Another academic novelty of this research is

employing for the first time STOPS as a framework for a cross-national comparison within the area of Natech risk communication.

Currently, only a few scholars have researched issues related to risk communication and community participation concerning Natech accidents (Yu, Cruz, & Hokugo, 2017; Yu & Hokugo, 2015; Funabashi, 2012; Cruz & Okada, 2008; Steinberg & Cruz, 2004). In fact, recent literature reviews emphasised the need to develop the emerging field of Natech risk communication and invited further research (Suarez-Paba et al., 2019; Cruz & Suarez-Paba, 2019). Answering this call, the current study hopes to contribute in advancing the Natech risk communication research and further offer useful input for Natech risk management and communication strategies.

The rest of this chapter is organised as follows. Section 3.2 offers a brief overview of the literature on cross-national risk perception and presents a conceptualisation of cultural differences considered in our approach. Additionally, we explain here our audience-based risk communication approach and finally we introduce the STOPS and OPR elements, along with any supplementary influencing factors used in this study. Section 3.3 presents the research hypotheses and data collection methods. Section 3.4 describes our dataset preparation and the multivariate and descriptive analysis methods employed. Section 3.5 includes the analysis results for our models together with their comparison, while Section 3.6 focuses on the results from the survey response comparison and public segmentation. Section 3.7 synthesises and discusses the key research findings and considers policy implications. The last section offers a summary, and considers the study's limitations and future research prospects.

3.2 Literature Review

3.2.1 Cross-national Risk Perception

Over the past 30 years, risk communication and perception studies have advanced significantly and expanded their research scope beyond that of a single country to involve cross-cultural approaches (Zhai & Suzuki, 2009; Rohrmann & Renn, 2000). Despite this evolution, critics noted that the majority of this literature had been traditionally concerned with western or industrialised countries (Zhai & Suzuki, 2009; Rohrmann & Renn, 2000). Of course, there have been instances where Asian countries—and particularly from the northeast of the continent—have been included in these comparisons, yet they are usually examined against Western countries in an attempt to highlight the differences between Eastern and Western cultures. A brief review of past studies demonstrates that they focused mainly on Japan and the US (Hirose, Slovic, & Ishizuka, 1994; Hinman et al., 1993; Kleinhesselink & Rosa, 1991), China and the US (Aliperti & Cruz, 2019; Weber, Ames, & Blais, 2005; Hsee & Weber, 1999; Weber & Hsee, 1998), China and Australia (Rohrmann & Chen, 1999; Bian & Keller, 1999), China and Austria (Schmidt & Wei, 2006), Korea and

Australia (Kim & Park, 2010), Korea, Japan, and the US (Cha, 2000) and Korea, China and Australia (Park, Kim, & Zhang, 2016). It should be mentioned, however, that the majority of all the aforementioned studies employed samples constituted by university students, and subsequently noted as one of their limitations the representativeness of their respective national populations.

There are fewer studies on risk perception with particular focus on cross-national comparisons amongst Asian countries. For instance, Zhai and Suzuki (2009) analysed individuals' perceptions for several types of risks across Japan, China and Korea, while He and Zhai (2015) explored the effects of spatial location on public risk perception about tsunami and flood hazards across the same set of countries. From a cross-national perspective, Zhai and Suzuki's (2009) findings showed that certain risks, such as nuclear accident risk and environmental pollution, were perceived as more severe in the Japanese sample compared to the Korean sample. Interestingly, nuclear accident risk was ranked low in terms of concern for all national groups, a finding which does not initially agree with the psychometric paradigm's argument that postulates that unfamiliarity with a risk leads to higher concern. On the other hand, although He and Zhai's (2015) primary focus was on investigating the effects of proximity to the hazard source on tsunami and flood risk perception, their results also revealed that S. Koreans generally perceived tsunami risk as more severe in comparison to the Japanese sample. As underscored by the researchers in the above two studies, cross-national studies on risk perception focusing on comparisons between Asian countries have only just started to emerge in the literature.

3.2.2 Conceptualising Cultural Differences

Etic and emic approaches have been used to conceptualise cultural differences in research. The etic approach is founded upon a universal, 'objective' and analyst-centred way of looking at culture, whereas emic approaches present a specific and context-rich way of describing culture (Avruch, 1998). The latter usually utilise and build upon indigenous concepts and culture-specific characteristics to explain sociocultural phenomena (Fetvadjiev & van de Vijver, 2015). In contrast, etic approaches place emphasis on identifying broader and generalisable concepts that characterise cultural variations across all cultures, i.e. universal characteristics (Fetvadjiev & van de Vijver, 2015). Etic cultural approaches, such as the dichotomous framework of Asian collectivism versus Western individualism (Rohrmann, 2000, p. 137) or the *cushion hypothesis* (Hsee & Weber, 1999), have often been applied to compare and interpret risk perception differences across cultures. In brief, the *cushion hypothesis* states that members from collectivistic sociocultural backgrounds are more likely to pursue risk-taking behaviour, since they expect to be supported from the collectivistic nature of their culture. Thus, any expected negative consequences are

shared across a number of people and the adverse effects felt by the individuals are diminished (Hsee & Weber, 1999).

One of the most prominent and influential etic approaches comes from the seminal work of Hofstede (1984), who proposed a model of cultural values or dimensions. This dimensional paradigm was introduced in the 1980's but has been gradually evolving ever since, receiving support and criticism alike (Hofstede, 2011). It has been the inspiration for numerous studies on national cultures that contributed to elaborating dimensions of the model through analyses from alternative perspectives, such as the work of Triandis (1995), Schwartz (1994) and Schwartz and Bardi (2001), or further expanding it with additional dimensions, such as the findings of the GLOBE project (i.e., Global Leadership and Organizational Behaviour Effectiveness) led by House et al. (2004). The latest version of Hofstede's model is comprised of six dimensions (they were four originally), namely *Power Distance*, *Uncertainty Avoidance*, *Individualism/Collectivism*, *Masculinity/ Femininity*, *Long-term/Short-term Orientation* and finally *Indulgence/Restraint*. Based on scores for each of these cultural dimensions, countries from around the world were assessed and positioned relative to one another. The six dimensions are presented next.

Power Distance represents the degree to which less powerful members of organisations and social institutions (like a family hierarchy) accept and expect power to be unequally distributed. It is a measure of social inequality and conceptualises the degree to which followers and leaders alike endorse it within their societal structure (Hofstede, 2011; Hofstede, Hofstede, & Minkov, 2010).

The bipolar scale of *Individualism* versus *Collectivism* is probably the most debated cultural dimension in the model. According to Hofstede (2011), this aspect conceptualises the level to which members of a society are integrated in social groups. Collectivistic cultures have a prominent 'we'-consciousness and their members typically form strong and cohesive in-groups of support (e.g., extended families). On the other end of the spectrum, individualist cultures are characterised by an *'I'-consciousness* that dictates rather loose member ties, as individuals are expected to take care of themselves and their immediate family (Hofstede, Hofstede, & Minkov, 2010).

The dimension of *Masculinity* versus *Femininity* describes the distribution of values between genders within a society. Based on findings from IBM studies, Hofstede et al. (2010) noted that value distributions in masculine cultures are quite different between genders as men tend to be more assertive and competitive from women in such societies. Contrary, in feminine cultures the value discrepancy between genders is smaller, as men show a tendency towards being modest and caring similar to that of women (Hofstede, 2011; Hofstede, Hofstede, & Minkov, 2010).

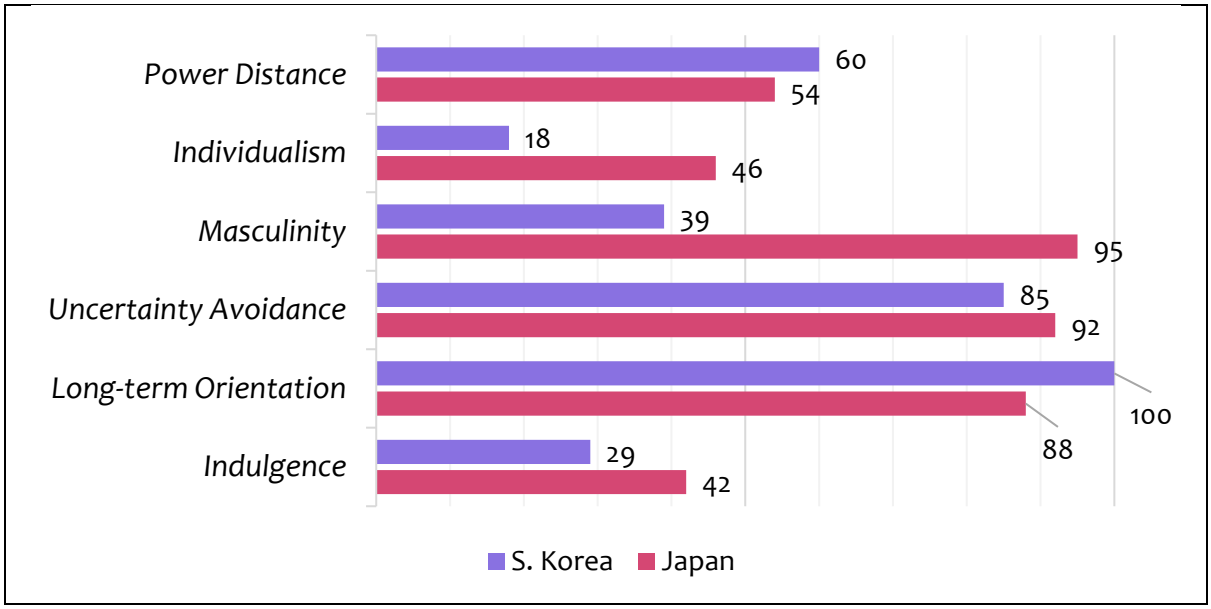
Uncertainty Avoidance is the fourth dimension from the original Hofstede (1984) model. It defines a society's tolerance for ambiguity, and in that regard does not translate directly to risk

aversion. In a sense it shows how comfortable the society is with unknown, unstructured and different situations. Cultures that tend to avoid such uncertain situations—usually through establishing strict behavioural codes, norms and rules—are characterised by a general disapproval of deviant opinions in their societal interactions (Hofstede, 2011; Hofstede, Hofstede, & Minkov, 2010).

The first extension of the Hofstede model came with the integration of the *Long-term* versus *Short-term Orientation* cultural dimension (Hofstede, 2011). Cultures with a stronger long-term orientation are typically associated with values of perseverance, economic thrift, evaluating relationships by status and having a sense of shame. On the other side, short-term oriented cultures usually place emphasis on values such as reciprocating social responsibilities, respect for tradition, saving one's 'face' and personal stability and steadiness (Hofstede, 2011; Hofstede, Hofstede, & Minkov, 2010).

The newest addition to the Hofstede model was the *Indulgence* versus *Restraint* dimension (Hofstede, Hofstede, & Minkov, 2010). It is a measure of aspects typically related to research on 'happiness'. Societies that score high on Indulgence generally tend to allow their members a relatively free fulfilment of basic human desires associated with having fun and enjoying life. In contrast, societies that show high restraint have a propensity towards controlling and regulating desire gratification through strict social norms (Hofstede, 2011; Hofstede, Hofstede, & Minkov, 2010).

Figure 3.2-1 Hofstede's 6-d cultural dimension scores for Japan and S. Korea



Source: Hofstede et al. (2010); own visualisation

Taking all the above into consideration, we employ this well-established etic conceptualisation of sociocultural dimensions to identify the similarities and differences between Japanese and Korean societies. Figure 3.2-1 summarises the scores for the two countries for each of the 6 cultural dimensions of Hofstede's model (Hofstede, Hofstede, & Minkov, 2010). At first glance, it becomes apparent that Japanese and S. Korean cultures are fairly similar. Both countries fall on the middle of the scale for the Power Distance dimension, thus indicating that they acknowledge and expect skewed power relationships within their respective societal structures to a certain degree. As Hofstede (2011) pointed out, Japan takes a middle position on the scale of Individualism, thus demonstrating a relative difference compared to the more collectivistic Korea. It should be highlighted though that Hofstede's model still categorises both societies as collectivistic in structure—both scored lower than the midpoint after all—yet Korean culture seems to have a relatively higher tendency towards the integration of individuals in social groups. The cultural dimension of Masculinity/Femininity seems to be the largest difference between the two societies. Indeed, masculinity is considerably high in Japan and moderately low in S. Korea (Hofstede, 2011), consequently showing that Koreans tend to be more modest and caring of others in comparison. Concerning the rest of the dimensions, Japan and S. Korea appear to follow the trends of other fellow East Asian societies. In detail, these societies seem to have rather strict social norms that do not favour the development of uncertain situations; they value more pragmatic, critical and long-term oriented approaches; and do not expect of their members to indulge their desires, enjoy, and have fun largely unconditionally.

In sum, Japanese and Korean cultures seem to share similarities in terms of Power Distance, Uncertainty Avoidance, Long-term Orientation and Indulgence. Additionally, they both fall in the Collectivism side of the spectrum and thus are generally regarded as collectivistic societies, even though this value is less pronounced in Japan. Finally, Korean culture is considerably more Feminine than the Japanese. Overall, we would argue that, with the exception of the Masculinity/Femininity dimension, Japanese and Korean societies are relatively similar.

Hofstede's cultural dimension model has been criticised as an approach that can be only applied to comparisons of business organisation culture at the national level (McSweeney, 2002). In fact, Sivakumar and Nakata (2001) argued that the approach may be rather overly simplistic in conceptualising the complexity of culture in a reductive way with a mere 4 to 6 dimensions. Moreover, Hofstede's initial dataset was comprised of managers and employees from a single multinational corporation and thus the findings are not generalisable to each respective country level. This approach also does not take into account the dynamic variability and development of

culture over time, and arguably presupposes a general cultural homogeneity within a country's culture (Kirkman, Lowe, & Gibson, 2006; Sivakumar & Nakata, 2001).

Culture is widely recognised by scholars as a large set of diverse and interdependent dimensions that may be identified at various levels of social organisation, such as business teams, organisations, nations and so forth (Beugelsdijk, Kostova, & Roth, 2017). A recent meta-analysis by Beugelsdijk et al. (2017) of several studies using this approach demonstrated that cultural differences and similarities tend to be more cohesive and pronounced when examining supra-national cultural clusters rather than comparing countries at the individual level. Such supra-national cultural clusters can be delineated based upon social and institutional factors that influence organisational practices, societal structures and values across regions comprised of multiple countries (Beugelsdijk, Kostova, & Roth, 2017; Taras, Steel, & Kirkman, 2016). The research findings by Taras et al. (2016) seem to support the argument that cultural profiles are actually supra-national, and that sociocultural context diversifies mostly between larger regions and less between countries belonging to the same cultural cluster.

To further support our argument about the cultural similarity of the two countries, we also examine their relative position considering supra-national cultural groups. According to the cultural clusters suggested by Ronen and Shenkar's (2013) meta-analysis on cultural dimension data from a host of studies, Japan and S. Korea are grouped together in the *'Confucian Asia'* global cultural cluster. Countries in this cultural cluster are characterised by a relatively low degree of individualism and large power distance. Moreover, they score high in terms of future and performance orientation, uncertainty avoidance, autonomous and self-protective leadership, reliance on vertical sources, following unwritten guidance rules and widespread beliefs (Ronen & Shenkar, 2013). It should be noted however that although Japan and S. Korea belong to the same global cultural cluster, they are both regarded as 'singletons' within it, meaning that there is relative dissimilarity between them and the rest of the cluster.

In sum, as becomes evident from the consistent findings from the studies of Hofstede et al. (2010) and Ronen and Shenkar (2013), Japan and S. Korea seem to share more similarities than differences in terms of their sociocultural background. Subsequent analyses showed that the dominant characteristics of each supra-national cultural cluster are shared—to an extent—between the countries of the group. Therefore, although we need to acknowledge any subtle cultural differences among Japanese and Koreans, the argument of relative cultural similarity between the two seems to be supported.

3.2.3 Audience-based Risk Communication

As explained in the introduction, the citizens' 'appetite' and perceptions for chemical and Natech risk information have not been extensively studied. Suffice to say, this is a new topic in the risk communication field, and so there exists no established theoretical framework to examine it. Access to risk information is understood in the current study as a means to engage citizens in disaster risk reduction processes aimed at promoting community preparedness against chemical accidents, and building capacity and consensus for participatory risk management methods. Naturally, a straightforward method of measuring community 'appetite' would be optimal, but the mere idea of 'appetite' towards chemical accident risk information disclosure is extremely vague and convoluted for non-experts to deal with.

Two major schools of thought exist in the study of risk perception (Kunz-Plapp & Werner, 2006): the paradigm of the Cultural Theory of Risk and the Psychometric Paradigm. According to Cultural Theory, the social and cultural typologies form the basis for the construction of the individuals' cognitive categories (Breakwell, 2007; Douglas & Wildavsky, 1982), whilst the Psychometric Paradigm approach transcends the individuals' sociocultural context, emphasising on traits that are shared across societal groups (Slovic, 2000; Slovic et al., 1981). There have been several approaches in health and risk communication literature based on the abovementioned paradigms—and particularly on the latter—attempting to understand and predict the individuals' information-seeking behaviour (for a review see Sheppard, Janoske, & Liu, 2012). Examples include the Risk Information Seeking and Processing model (*RISP*; Griffin, Dunwoody, & Neuwirth, 1999), the Theory of Planned Behaviour (*TPB*; Ajzen, 1991) and the Extended Parallel Process Model (*EPPM*; Witte, 1992). Common motifs in such theories are that individuals' risk perception and affect drive information seeking, and that self-efficacy defines behavioural change and information processing. However, what seems to be still lacking is a methodology to examine citizen communicative behaviour concerning disaster risk information. From a communications perspective, the essence of the query can be distilled to understanding how publics process risk messages; how citizens communicate about the risk itself and the associated information disclosure issue.

Diverging from the narrative of perceived hazard characteristics as the key drivers of information-seeking behaviour, this research ventures to assess the perceived problem of chemical risk information deficiency by looking at how individuals communicate through acquiring, selecting and transmitting information about it. Due to the nature of this research lying on the verge of risk communication and public relations, various interesting normative conceptual models and interpretative frameworks present as potential solutions for the methodological gap at hand. The

Situational Theory of Problem Solving (STOPS) seems to provide superior advantages over others in dealing with certain central issues.

As Fischhoff (2006) pointed out, an important task in risk management is to translate scientific findings into applicable and meaningful suggestions for the communication of risk information. In this regard, it is crucial for risk communicators to identify, evaluate and understand the factors influencing public perceptions, so that their messages could be effectively adapted to meet the needs of specific individuals or target audiences. These factors involve among others people's beliefs, judgments and feelings, as well as their sociocultural values and their attitudes towards hazards and associated offsetting benefits (Kaptan, Shiloh, & Onkal, 2013). Identifying such aspects and examining their variability within and across audiences holds significant value for risk management, through for example increasing community support for a proposed course of actions.

Risk communication approaches based on analysing and segmenting audiences examine a variety of audience attributes with the aim of helping organisations and risk managers to plan effective and targeted communication strategies where needed (Fraustino & Liu, 2017). The main argument is that by identifying the persistent and situational characteristics of key audiences within the broader public, organisations will be at a better position of ensuring that their risk communication efforts include the content that is most helpful to and best received by crucial stakeholder groups. This concept of tailoring communication strategies to specific audiences, however, has also received criticism on the grounds that it can easily be used by organisations to silence audiences with interests conflicting to their own, instead of trying to inform and empower them (Fraustino & Liu, 2017).

The *Situational Theory of Publics (STP)* as well as the *Situational Theory of Problem Solving* fit in the category of audience-based risk communication approaches (Fraustino & Liu, 2017). Even though they have been extensively employed in the field of public relations, only limited research has applied these frameworks in the context of disaster risk management. As noted by Fraustino and Liu (2017), both the STP and STOPS frameworks still present promising approaches for risk communication research. In fact, only a recent study by Liu et al. (2019) has employed the STOPS framework and integrated it with Social-Mediated Crises Communication (SMCC) theory to try and understand how individuals communicate and respond to tornados in the US. Their research findings are indeed significant as one of the first studies to empirically test and confirm the internal validity of the STOPS framework with respect to communication about a natural hazard.

Nonetheless, Liu et al. (2019) particularly focused on crisis communication and public response in the face of imminent threat from tornados. In this regard, their results highlighted

certain shortcomings of the STOPS framework in predicting intended protective actions for tornados, which were able to be overcome through the combination and extension of STOPS with the SMCC, along with some additional descriptive factors. However, disaster risk communication is typically distinguished in three phases with respect to the hazardous event phases (Sheppard, Janoske, & Liu, 2012), that is pre-event risk communication, response (or crisis) communication and recovery communication. Considering this, we would argue that the STOPS framework has not been tested so far in the broader context of the disaster risk communication that includes all these phases.

In an attempt to identify, empower and engage with the affective part of citizens exposed to Natech accident risk, a theoretical framework beyond the perception and social psychology of risk is employed; an approach that focuses on *'communicative actors'*. Communicative actors are not only expected to diligently search for, review and synthesise any available information pertaining to the issue, but are also more likely to reciprocate the efforts and engage in two-way communication (Grunig & Kim, 2017). In this respect, by focusing on communicatively active publics, risk communicators have an opportunity to learn more about the community's demands, fears and (mis-)perceptions concerning the risk in order to effectively balance the interests of the communicating parties (Grunig, 2018; Ni et al., 2015). Such audience-oriented risk communication approaches that are based on analysing and segmenting audiences can assist organizations and risk managers in drafting effective and targeted communication strategies where needed (Fraustino & Liu, 2017). Adhering to a participatory risk management approach that emphasises citizen engagement, it is imperative to introduce an interpretative framework to identify such legitimate actors within the community and appreciate their communicative behaviour. The STOPS offered this conceptual background, as it explains such exigent publics and predicts who will communicate actively (Kim and Grunig 2011).

Through the interpretative framework of STOPS emphasis is placed upon understanding why and how problem-solving begins and what are the communicative characteristics the solver exhibits (Kim & Krishna, 2014). In terms of risk communication, this approach provides valuable insight into how the community actually perceives and processes the problematic situation. Furthermore, one of the core ideas of STOPS is that the public opinion concerning the issue at hand is expressed via the communicative behaviour the individuals assert in order to solve it (Kim & Krishna, 2014). This is a fundamental argument for the purposes of this research. In detail, applying this reasoning permits a direct and in-depth analysis of the residents' interpretation of the problematic situation, which arises from the lack of disclosed Natech risk information. In other words, the community's 'appetite' for risk information can be (in-)directly gauged in this way.

Additionally, according to Sheppard et al. (2012), who offered an exhaustive review of risk communication theories and models, STOPS falls under the category of cross-cutting theories that are applicable in multiple risk phases (i.e., preparedness, response and recovery). Communicative behaviour may be examined before an actual chemical accident occurs through the STOPS model. Thus, understanding the publics' perceptions of the situation and motivation for communicative action, allows the research to focus on the risk preparedness stages. Risk managers are not restricted from evaluating the citizens' communicative behaviour only during or after a hazardous event, but instead they can plan ahead effective strategies for disclosing and disseminating information and actively engaging publics in risk reduction processes (Sheppard, Janoske, & Liu, 2012).

STOPS was initially proposed as a generalised theory of problem-solving (Kim & Grunig, 2011). Although, it originated from the academic arena of public relations, its applications soon transcended those boundaries as a framework to investigate and understand a broader spectrum of strategic communication processes. STOPS has been primarily applied in the public relations and organisation communication fields. Concerning the former discipline, researchers employed the theory to understand business employee communication patterns (Kim & Rhee, 2011), evaluate relationship quality between citizens and civic organisations in regard to urban issues (Lovari, Martino, & Kim, 2012), and study post-crises external communication behaviours between businesses and their customers (Kim, Miller, & Chon, 2016) or government organisations and the public (Chon, 2019). In the latter field, STOPS helped researchers explain the phenomenon of '*cyberactivism*' (i.e. situation-triggered online flaming) in computer-mediated communication (Kim & Kim, 2009) and social media activism concerning contentious issues (Chon & Park, 2019), study government-citizen communication strategies (Lee, 2016), as well as describe communicative behaviours of hot-issue publics, who are active on media issues in a socio-political context (Chen, Hung-Baesecke, & Kim, 2017; Kim et al., 2012). In addition, STOPS has been employed in the arena of health communication to elucidate organ and health donor shortages focusing on public concerns (Kim, Shen, & Morgan, 2011), and to illuminate the issue of '*cybercoping*' (i.e. coping with health issues by the communicative interactions among networked online publics) (Kim & Lee, 2014). Also, it has been used to interpret issues of sociological public diplomacy (Kim & Ni, 2011), and to assess communicative action among farmers pertaining to agricultural technology information failures (Ismail, Sabran, & Ariffin, 2017). There has been one application of the STP (see Grunig, 1997), the predecessor of STOPS, to the field of crisis communication looking at public perceptions vis-à-vis terrorist attacks (Aldoory, Kim, & Tindall, 2010). Finally, it is noteworthy that only recently Liu et al. (2019) applied the STOPS framework to investigate the communicative

behaviour and response actions of the public with regards to tornado warnings. Thus, concerning the research area of disaster risk management and risk communication this methodology has not been employed yet in the context of chemical or Natech accidents.

Apart from the above, it should be noted that STOPS has been successfully applied in a plethora of sociocultural settings. In detail, these include western cultures such as the US (Chon & Park, 2019; Kim, Shen, & Morgan, 2011; Kim & Grunig, 2011) and Italy (Lovari, Martino, & Kim, 2012), but also countries with Asian cultural characteristics, such as S. Korea (Chon, 2019; Lee, 2016; Kim et al., 2012), Taiwan (Chen, Hung-Baesecke, & Kim, 2017) and Malaysia (Ismail, Sabran, & Ariffin, 2017). Prior to this work[10], STOPS has not been tested in the unique sociocultural setting of Japan.

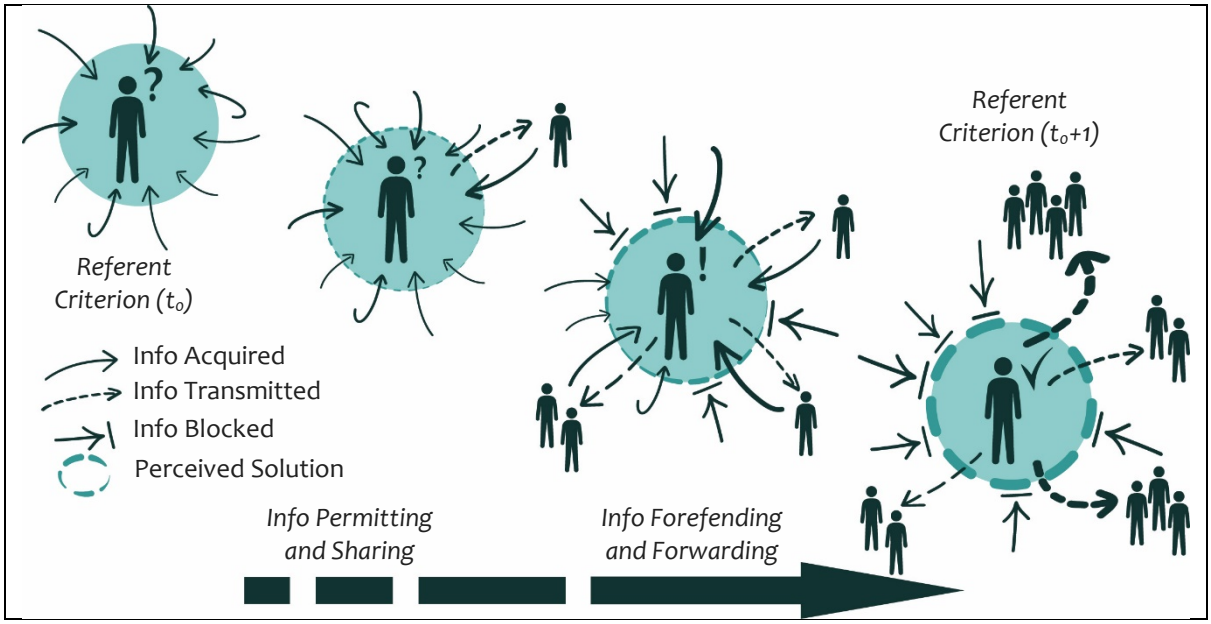
3.2.4 Situational Theory of Problem Solving (STOPS)

STOPS asserts that communication is purposeful. It is not the by-product of problem-solving communicative action, but rather its manifestation. Kim and Grunig (2011, p. 125), the original authors, define the theory's general postulate as follows: '*the more one commits to problem resolution, the more one becomes acquisitive of information pertaining to the problem, selective in dealing with information and transmissive in giving it to others*'.

This means that, individuals set in motion a certain communicative process, when they commit themselves to solve a newly presented problem (see Figure 3.2-2) (Kim & Krishna, 2014; Kim & Grunig, 2011). At first, they begin to search for information about how to solve the issue (t_o). Since they face a problematic situation for the first time, individual perceptions concerning an appropriate solution are weak at best. Therefore, they collect information from various sources they come across in order to enrich their understanding about the issue and find a suitable solution. However, as individuals gradually acquire information and communicate ideas with others, they progressively construct their subjective opinion about how to effectively address this issue. In this way, instead of blindly gathering any information they come across, they judge ever more rigorously the input based on their subjective understanding of the situation, discarding any information they deem as conflicting with their opinion. In parallel, individuals actively transmit information they had previously acquired so as to exchange ideas with others in their quest for resolving the presented problem according to their standards. At the final stage (t_o+1), individuals have formed a concrete opinion about the appropriate solution, and consequently block any additional input as redundant. They try to 'recruit' others to their cause and collectively pursue on resolving the initial problem based on their common understanding.

[10] The research project employing and evaluating STOPS in Japan for the first time has begun during the author's Master's degree research (see Tzioutzios, 2019).

Figure 3.2-2 Conceptualisation of Communicative Behaviour



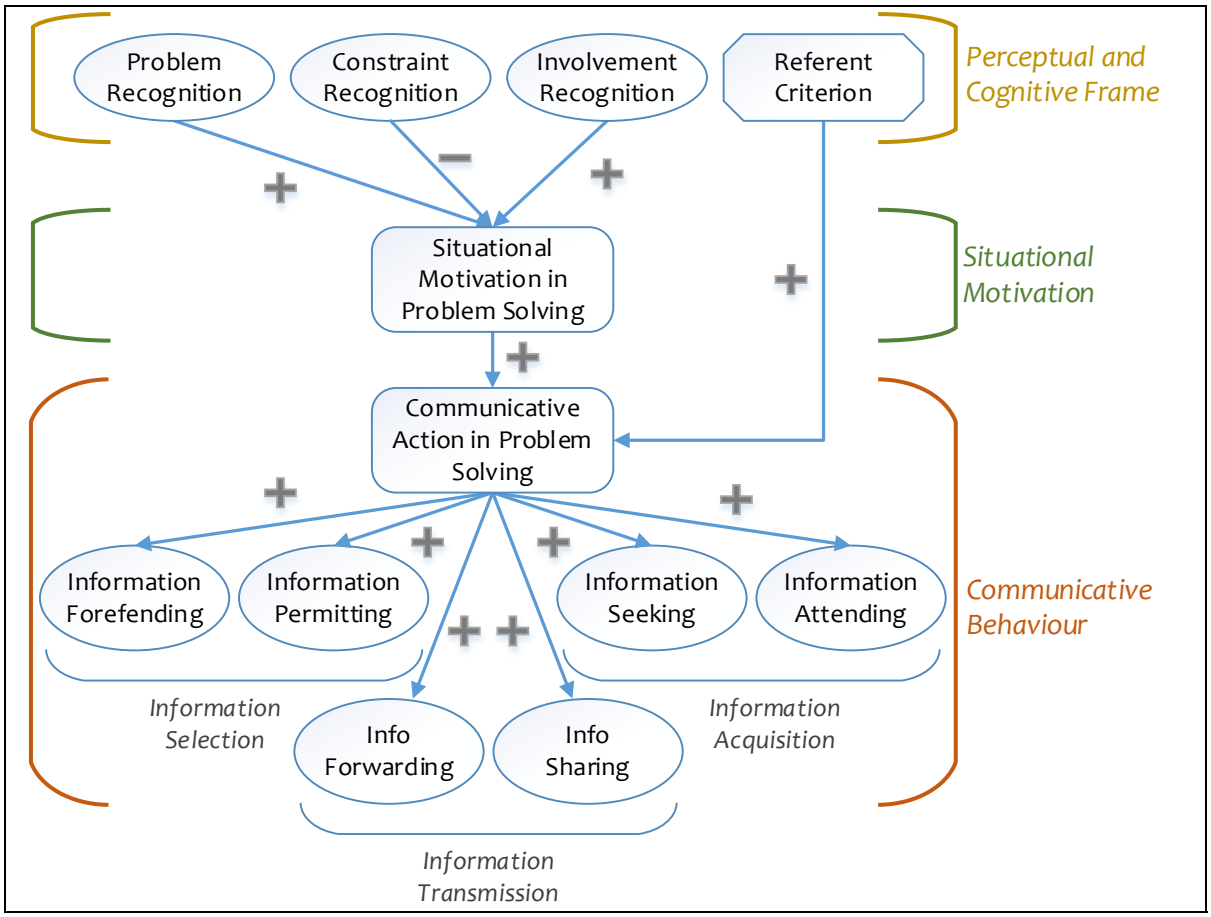
Source: Based on Kim and Krishna (2014, p. 86); own visualisation

The abovementioned narrative can be summarised into one conceptual model (Figure 3.2-3). Three main parts can be distinguished initially: the perceptual and cognitive frame, the situational motivation and the communicative behaviour. The components of each part in turn are elaborated next.

The perceptual and cognitive frame is defined by four situational antecedents, in detail three perceptive variables and one cognitive. ***Problem Recognition (PR)***: A problematic situation presents itself through the perceived discrepancy between an individual's expectations and their experiential reality. This realisation that something is missing and that there is no immediately applicable solution to it is defined as problem recognition (Chen, Hung-Baesecke, & Kim, 2017; Kim & Krishna, 2014; Kim & Grunig, 2011). ***Involvement Recognition (IR)***: Each person lives according to their own perceived reality, rather than in an objective reality. Therefore, the level of association one perceives with a given issue may not necessarily coincide with their actual connection to the problematic situation (Chen, Hung-Baesecke, & Kim, 2017). Expanding on this premise, involvement recognition is conceptualised as the perceived connection between individuals and the problematic situation (Kim & Krishna, 2014; Kim & Grunig, 2011). ***Constraint Recognition (CR)***: This is the final perceptual variable. Constraint recognition can be understood as a measure of the perceived obstacles which prevent individuals from taking action towards resolving the problematic situation (Chen, Hung-Baesecke, & Kim, 2017; Kim & Krishna, 2014; Kim & Grunig, 2011). ***Referent Criterion (RC)***: The referent criterion is the cognitive factor of the situational antecedents. It is defined as any prior knowledge, experiences, expectations and subjective judgmental rules an

individual activates or improvises in the cognitive process to solve current problems (Kim & Krishna, 2014; Kim & Grunig, 2011). Referent criteria provide guidelines for solution finding and influence the way a person approaches the problem. RC is conceptualised to intensify all dimensions of communicative behaviour for problem-solving (Chen, Hung-Baesecke, & Kim, 2017).

Figure 3.2-3 Conceptualisation of the Situational Theory of Problem Solving



Source: Kim and Grunig (2011, p. 121); own visualisation

Situational motivation acts as the mediator between the situational antecedents and the communicative action. ***Situational Motivation in Problem Solving (SM)***: Kim and Grunig (2011, p. 16) identified this variable as a measure of '*the extent to which a person stops to think about, is curious about, or wants more understanding of a problem*'. It is a motivational concept that mediates the effects of the three perceptual aspects (i.e., problem recognition, involvement recognition and constraint recognition). In detail, the recognition of a problematic situation, the perceived connection between the individual and the problem along with the absence of apparent barriers in doing something about it (i.e. reversed constraint recognition) increase the situational motivation to engage in communicative action (Kim & Krishna, 2014). Subsequently, situational

motivation, along with the influence of activated or improvised reference criteria, encourages the engagement in communicative action (Chen, Hung-Baesecke, & Kim, 2017; Kim & Grunig, 2011).

The final part of the STOPS model describes the individuals' communicative behaviour. ***Communicative Action in Problem Solving (CAPS)***: CAPS is conceptualised as a second-order composite factor that incorporates three dimensions of communicative behaviour individuals adopt when attempting to resolve an issue (i.e., information acquisition, selection and transmission). In turn, each of these dimensions is characterised by two approaches: one passive and one active expression. In other words, Kim and Grunig (2011) proposed CAPS as a construct of six sub-factors, which define the reactive (i.e., '*heuristic*') and proactive (i.e., '*systematic*') attitudes, respectively. It is important to note that passive problem-solvers are likely to engage in only passive communicative actions, whilst active problem-solvers tend to display both active and passive communicative behaviours. Therefore, CAPS assumes a positive association with all involved actions (Chen, Hung-Baesecke, & Kim, 2017; Kim & Krishna, 2014; Kim & Grunig, 2011).

The three communicative dimensions are discussed next. The active and passive components for each dimension are explained in order. ***Information Acquisition***: ***Information Attending (IAtt)*** and ***Information Seeking (ISek)***. Attending describes the effortless discovery of messages, while seeking the planned scanning of the individual's environment for messages related to the specific problem. ***Information Selection***: ***Information Permitting (IPrm)*** and ***Information Forefending (IFrf)***. Permitting means a passive acceptance of messages from various sources, whereas forefending is the specific and systematic selection of information relevant to an individual's subjective opinion for suitable solution. ***Information Transmission***: ***Information Sharing (IShr)*** and ***Information Forwarding (IFwd)***. Sharing refers to a reactive stance concerning information sharing only when asked to, while forwarding is a proactive form of information communication of perception and possible solutions (Chen, Hung-Baesecke, & Kim, 2017; Kim & Krishna, 2014; Kim & Grunig, 2011).

Translating STOPS into the context of Natech risk communication, citizens evaluate the presented problematic situation stemming from the risk information deficiency, their personal connection with the issue and the barriers that limit their ability to take action in resolving it. According to their knowledge, subjective judgemental rules (e.g., moral or cultural issues) and expectations about how chemical and Natech risk information should be handled, their situational motivation impels them to engage into communicative action. Interestingly, the potential Natech accident risk local residents are imperceptibly subject to because they live near industrial facilities in areas exposed to natural hazards, sets the stage of the initial problematic situation. However, this study enquires about the *cognitive meta-problem* deriving from the lack of publicly available

information concerning this problematic situation (*perceptual problem*). According to Kim and Grunig (2011), this secondary *cognitive meta-problem* comes into existence due to the absence of a readymade solution for the primary *perceptual problem*. Although the perception about this *meta-problem* is not the same as the Natech risk perception, the logical connection among them can be logically inferred; the higher the concern about a potential Natech risk, the larger the problem of information deficiency becomes. Therefore, the main argument is that the situational perception about the lack of risk information can be considered as a representation of the underlying perception about the associated Natech risk.

Another fascinating point is that, there is a multitude of perceptions and opinions about a single issue from the various social subgroups included in a community. Behavioural approaches dictate that information dissemination is not uniform across all the involved stakeholders and that individuals do not always make perfectly rational decisions that maximise their economic efficiency. Instead, several psychological and social factors influence individuals' assessment of the situation at hand, and consequently shape their course of action. Situational theories from public relations and communication disciplines introduced the notion that, such decisions are reflected in individuals' communicative behaviour as well, shaping the ways individuals seek out, process and share information (Kim & Krishna, 2014; Kim & Grunig, 2011; Grunig, 1997).

The lynchpin idea (STP and) STOPS is that the general public is not homogeneous *vis-á-vis* the communicative behaviour they adopt towards a certain problem. Therefore, within what is conceived as 'general public', individuals can be actually divided into four main categories according to their perceptual and cognitive characteristics pertaining to the problem (Kim & Grunig, 2011), namely '*non-publics*', '*latent publics*', '*aware publics*' and '*active/activist publics*'. Each of these types exemplifies different communicative behaviour based on their interest—or lack thereof—to resolve the issue of concern (Kim & Ni, 2013; Kim, 2011). In brief, non-publics consist of individuals who perceive no initial problematic situation and therefore neither involvement nor constraints; latent publics perceive a problem through its consequences, but have yet to detect it; aware publics have recognised the issue, but have not taken any action to resolve it; and active/activist publics have started coordinating their actions on solving the problem either as individuals or in a more collective fashion (Kim & Ni, 2013; Kim, 2011).

Expanding on this argument, conducting such kind of formative research to segment into different groups the 'general public' prior to developing and implementing a risk communication campaign is indispensable. Strategic research allows risk managers to identify, approach and learn from a multitude of actor groups within the community. On the other hand, risk communicators

can formulate strategies tailored for the exact needs and characteristics of each group so as to target effectively publics of specific interest (Kim & Ni, 2013; Kim & Grunig, 2011).

3.2.5 Organisation-Public Relationship (OPR)

As explained in previous sections, transparency and information disclosure can facilitate communities' participation in disaster risk management processes. Publics are becoming increasingly interested in understanding and interacting with entities that have consequences on their lives and their societies (Hon, 2006). Furthermore, confidence in the amount of risk information and in the accuracy of what is being communicated is closely associated with risk perception (Mileti & Peek, 2000). As Hon (2006, p. 61) put it, '*failure to disclose breeds suspicion that an organization has something to hide*'. It becomes apparent that the social climate, which defines the quality of the relationship between community and organisation, is a vital aspect for the efficiency and effectiveness of risk communication (Renn & Kastenholz, 2000); this argument gains specific importance considering the omnipresent chemical and Natech risk that involves both private and government organisations.

According to Hon and Grunig (1999), transparency in the decision-making processes plays a central role in creating and maintaining meaningful and fruitful relationships between publics and organisations. However, transparency is not just about access to information (Palenchar & Heath, 2007); it entails creating an atmosphere of mutual trust and cooperation among all stakeholders and stake-seekers. Increased levels of trust have been found to reduce social uncertainties, affect risk perceptions and encourage risk acceptance (Rogers et al., 2007), while trust-building brings policymakers and citizens closer to deliberate cooperatively in the context of disaster risk management (Hatori, Kobayashi, & Jeong, 2011). Moreover, publics that perceive fairness in the risk-related policymaking are keener on keeping or mending the relationship with risk communicators (McComas, Besley, & Yang, 2008). Overall, risk communication on the basis of organisational trust and meaningful community dialogue increases public support for decisions made by and/or presented by risk managers (Aven & Renn, 2010; Renn, 2006).

In this vein, government and business organisations are incentivised to invest in public relations in order to enhance their effectiveness through improving their relationships with strategic publics (Grunig, Dozier, & Grunig, 2002). Public relations researchers investigated three main steps of relationship cultivation: the antecedents of relationships, relationship cultivation strategies, as well as the outcomes of relationships (Broom, Casey, & Ritchey, 2000). Research on organisation–public relationships (OPR) has successfully employed the OPR assessment measures across various types of organisations in diverse contexts, targeting different kinds of publics (Chon, 2019; Ki, Kim, & Ledingham, 2015). Empirical results have indeed confirmed that positive OPR

outcomes lead to positive attitudes and behaviours of publics towards organisations (Chon, 2019; Ki & Hon, 2007; Bruning & Galloway, 2003). It becomes apparent that an overall positive OPR is important in disaster risk management for stakeholder organisations. Moreover, the OPR assessment scale has been utilised in the field of crisis communication to analyse and predict crisis outcomes. Prior crisis communication research using OPR outcomes has highlighted the importance of relationship management and public communication even before a crisis occurs (Chon, 2019). Establishing and maintaining positive relationships has been found to diminish the negative impact of the crisis on the organisation and the overall cooperation environment, whereas less favourable relations further exacerbate negative reputation on organisations (Chon, 2019; Coombs & Holladay, 2002, 2006; Ulmer, 2001). Consequently, constructive OPR are important in decreasing the negative communication consequences when a crisis occurs.

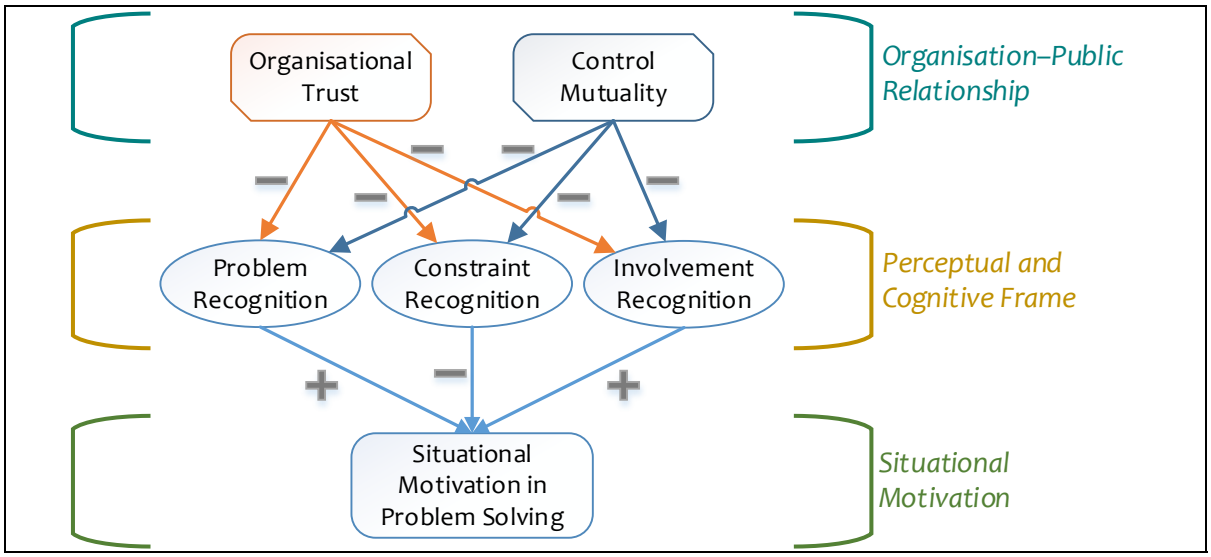
In our research context, evidently, creating and maintaining a favourable communication climate among involved stakeholders has profound implications for chemical and Natech risk communication. Therefore, appreciating the level of transparency citizens construe would help paint a more comprehensive picture about their perceptions and expectations concerning the chemical risk and the information deficiency issue. Of course, public relations academics have long contemplated matters of transparency and what constitutes meaningful organisation-public relationships. The seminal work of Grunig and Hon (1999) originally conceptualised six key dimensions to measure the quality of such relationships, which were later refined and explicated further (Grunig & Grunig, 2001; Huang, 2001); those were *Trust*, *Control Mutuality*, *Commitment*, *Satisfaction*, *Communal Relationships* and finally *Exchange Relationships*. Grunig and Grunig (2001) tested these measures and concluded that the first two are the most consistent among them. Thus, Trust and Control Mutuality were additionally included in the current study as reliable measures that characterise the quality of OPR. They are elaborated next.

Organisational Trust (OT): Trust refers to the level of confidence between publics and organisations and the willingness to open to one another; this is typically incrementally acquired and strengthened over time. OT is comprised of three main elements (Grunig & Grunig, 2001; Huang, 2001; Grunig & Hon, 1999). Integrity is the belief that an organisation's actions are fair and just. Dependability describes the belief that an organisation will do exactly as what it promises. Finally, competence is the belief that an organisation has the ability to accomplish what it promises.

Control Mutuality (CM): CM is defined as the degree to which publics and organisations agree on who holds the rightful power to influence the decisions of one another (Grunig & Grunig, 2001; Huang, 2001; Grunig & Hon, 1999). Although some imbalance is generally expected, Grunig

and Grunig (2001) advocate that a stable and positive relationship between organisations and publics is characterised by some degree of mutual control.

Figure 3.2-4 Conceptualisation of the Effect of Organisation-Public Relationship on Situational Perception



Source: Original work

Trust is a well-recognised concept in the field of disaster risk management. It is considered an important factor that influences judgements of risk and benefit, technology acceptance as well as other forms of cooperation (Slovic, 1999). In addition, institutional credibility entails providing the evidence of being cost-effective and open to public demands, therefore fairness and flexibility are major elements of organisational transparency (Renn & Kastenholz, 2000). In this regard, control mutuality is a straightforward notion of conceptualising the power balance climate between publics and organisations; the established checks and balances in controlling the risk-related decision-making process (Renn & Kastenholz, 2000).

Consequently, Organisational Trust and Control Mutuality constitute measures of evaluating the perceived quality of OPR in the context of this study. As explained earlier, a more favourable atmosphere among the stakeholders involved in chemical risk management, reduces the publics' concerns about the risk and, by extension, about the *meta-problem* of information deficiency. In sum, institutional credibility and power balance in decision-making are expected to alleviate the problematic situation from the citizens' perspective (Figure 3.2-4).

3.2.6 Additional Influencing Factors

The inherently complex nature of Natech accidents only complicates this already intricate and delicate issue. Understandably perceptions about the original Natech risk itself play a central role. When it comes to public (mis-)perceptions, three main risk characteristics have been

identified in the literature based on the seminal work of Slovic et al. (1981). First, an individual's perceived lack of control and high catastrophic potential instigates a degree of concern to the public; this factor is labelled *'dread'* (Savage, 1993; Slovic et al., 1981). The second factor is risk unfamiliarity, and relates to hazards that are new or yet unknown to the public, or perhaps have a delayed manifestation of consequences (Savage, 1993; Slovic et al., 1981). The final risk characteristic that affects perception is defined by the personal exposure to the hazardous situation (Savage, 1993; Slovic et al., 1981). Later, Slovic and Weber (2002) proceeded to categorise various types of risk based on this framework. The risks associated with nuclear accidents and radioactive waste disposal were examined among others, and the lay persons perceived both of them as highly dreadful, unknown and with extended consequences for many persons. Now, even though Natech risk was not considered in that study, it can be argued that its classification would be about the same, based on the similarities between technological and radiological hazards. Indeed, risks involving chemical, biological, radiological or nuclear accidents are characterised by lower familiarity and higher levels of dread (Sheppard, Janoske, & Liu, 2012).

Furthermore, risk perception has substantial implications for property values. A study on the impact of the perceived risk associated with a hazardous waste site upon the nearby land prices evidenced an inverse correlation; increased risk perception meant lower values for the properties surrounding the site (McCluskey & Rausser, 2001). Particularly in the context of Japan, Nakagawa et al. (2007) looked into the effects of perceived earthquake risk on housing rents in the region of Tokyo. Housing rent was considerably decreased in zones exposed to higher earthquake risk. On a follow-up study two years later, the researchers confirmed the observed effects on land prices (Nakagawa, Saito, & Yamaga, 2009). Thus, they concluded that higher earthquake risk correlates consistently with lower property value, findings that were supported in later research, as well (Naoi, Sumita, & Seko, 2010). To an even broader level, public risk perception has been found to have a negative effect on various aspects of the local economy. A study of Slovic et al. (1991) concerning the potential impact from a proposed nuclear waste repository in Nevada, revealed serious economic challenges for tourism, retirement and job-related migration and business development. The stigmatisation of the region as a direct result from public risk perceptions and socially amplified reactions to issues related to the nuclear repository (e.g. mismanagement and radiation releases), they argued, could potentially trigger significant adverse effects for the economy not only of the region, but of the whole state (Slovic et al., 1991).

Apart from the above, risk communication processes and behaviours, like any form of communication, cannot be understood when isolated from the specific sociocultural setting in which they are deeply embedded. The way communities and administrative institutions are

organised in a particular society dictate to a great extent the communicative actions the involved stakeholders engage into. This is particularly the case considering the conceptualisation of STOPS, where individuals are regarded as social actors that interact with organisations and each other (Kim & Krishna, 2014). Research focusing on understanding this organisational culture has demonstrated the outstanding differences the collectivistic societies present in contrast to western cultures. For example, based on Hofstede's (2001) model, Japan and S. Korea are relatively collectivistic cultures, while Japan is also quite male-dominated (masculine). Several subsequent studies have noted a tendency of individuals from collectivistic and masculine cultural backgrounds to avoid invoking community criticism by conforming to social norms (Lalwani, Shrum, & Chiu, 2009; Bernardi, 2006). This social desirability may be a crucial conceptual component in better comprehending citizens' 'appetite' for Natech risk information. The desire to socially conform to the already established rules and situations may act as an inhibiting factor for Japanese and Koreans to challenge the *status quo* concerning the availability and distribution channels of chemical and Natech risk information to the citizens.

Another point related to social desirability is the actual bias that may be introduced during data collection. A recent study compared Japan, Korea, United States and the Netherlands—all nations with different cultural backgrounds from one another according to Hofstede's dimensions—to conclude that, although respondents in self-report measures from both collectivistic and individualistic countries were likely to give more '*socially acceptable*' answers, the magnitude and pattern of this bias was stronger and more consistent in collectivistic countries (Kim & Kim, 2016). Additionally, Japanese researchers discovered evidence which supported the reasoning that the specific cultural background can significantly impact social desirability bias (Kondo et al., 2010). As a matter of fact, Kondo et al. (2010) found that Japanese respondents were seven times more likely to shed their social desirability inhibitions and select '*socially unacceptable*' options in a survey, if the majority of the preceding respondents had also chosen the same option. In any case, social desirability presents a very interesting notion and a major challenge in this particular study from both an interpretative and methodological perspective.

Lastly, the sociocultural fabric provides the mechanisms through which conspiracy theories emerge and are sustained. False beliefs about the causes of an issue can spread and grow to an extent where they might even become harmful for the processes the community uses to communicate. Public concerns about an issue—whether warranted or not—may be triggered from a past incident that is '*cognitively available*' (Sunstein & Vermeule, 2009). This is usually the case of many conspiracies related to technological risks, such as nuclear power or hazardous waste disposal sites, as Kuran and Sunstein (1999) note. A specific event becomes 'available' and soon

conspiracy theories emerge, attempting to either explain it or use it as symbol for broader social narratives, spreading suspicions for conventionally accepted wisdom in various domains (Sunstein & Vermeule, 2009). In terms of chemical accident risk, it is easily conceivable how conspiracy theories if left unchecked by the responsible authorities can wreak havoc in public-organisation relationships. In the framework of this particular study, potential conspiracy theories may not only damage the reputation of the involved government institutions and private stakeholders, but furthermore they may cultivate a generalised belief that any hazard and risk information provided by official sources is deliberately misleading and should be regarded with considerable doubt.

3.3 Methodology

3.3.1 Hypotheses

This study focuses on the meta-problem of Natech risk information deficiency and tries to understand the differences through a cross-national comparison. The main research question is: ***What are the differences in the communicative behaviour of citizens in Japan and S. Korea concerning the issue of Natech risk information disclosure?*** The crux of our main argument is that, Korean citizens are more motivated to communicate about Natech risk information disclosure and do so more actively in contrast to Japanese, since they have been already introduced to chemical risk communication. Moreover, the favourable cooperation climate between risk management organisations and the public, facilitated by risk communication, alleviates the perceived meta-problem of Natech risk information deficiency. In order to inquire these issues, we set out to examine the following hypotheses.

Examining the first postulate through the prism of STOPS there are eight conditions to be met. Compared to Japanese, Korean citizens have an increased situational motivation to communicate and resolve the meta-problem of Natech risk information deficiency (***H1***). Also, the available ideas for solution are more pronounced for Koreans, as they are more familiar with chemical risk communication (***H2***). These conditions contribute to an increased communicative activeness for Koreans in contrast to Japanese. In detail, Koreans are expected to be more active in terms of information forefending (***$H3_a$***), permitting (***$H3_b$***), forwarding (***$H4_a$***), sharing (***$H4_b$***), seeking (***$H5_a$***) and attending (***$H5_b$***).

- ***H1***: Situational Motivation is higher for Korean citizens.
- ***H2***: Referent Criteria are more pronounced for Korean citizens.
- ***$H3_a$***: Information Forefending is higher for Korean citizens.
- ***$H3_b$***: Information Permitting is higher for Korean citizens.
- ***$H4_a$***: Information Forwarding is higher for Korean citizens.

- ***H4b***: Information Sharing is higher for Korean citizens.
- ***H5a***: Information Seeking is higher for Korean citizens.
- ***H5b***: Information Attending is higher for Korean citizens.

As far as the second argument is concerned, S. Korea has invested in cultivating a positive milieu based on trust and shared decision-making control between organisations and the public through the recent chemical risk communication efforts. Thus, Korean citizens are hypothesised to have higher organisational trust (***H6***) and perceived control mutuality (***H7***) for related government institutions and businesses.

- ***H6***: Organisational Trust is higher for Korean citizens.
- ***H7***: Control Mutuality is higher for Korean citizens.

Moreover, the problematic situation regarding the risk information deficiency can be improved, if citizens are confident in the way the government and involved businesses address the issue of Natech risk information disclosure. In other words, if they trust how government and industry handle Natech risk information, they do not consider it be a serious problem they need to personally be involved with. Therefore, trust is expected to reduce the perceived severity of the meta-problem (***H8a***) and the perceived connection with it (***H8b***). Likewise, perceiving balance in the power relationship with said organisations about how the Natech risk information is managed also moderates public concerns. Therefore, sharing decision-making power is hypothesised to increase the citizens' perceived personal involvement with the meta-problem of Natech risk information deficiency (***H9a***)—as they can personally influence decisions on the matter—and reduce any perceived obstacles pertaining to its solution (***H9b***). It should be noted that, we expect to observe a positive influence from organisational trust and control mutuality for both Japanese and Korean samples.

- ***H8a***: Organisational Trust has a negative effect on Problem Recognition.
- ***H8b***: Organisational Trust has a negative effect on Involvement Recognition.
- ***H9a***: Control Mutuality has a positive effect on Involvement Recognition.
- ***H9b***: Control Mutuality has a negative effect on Constraint Recognition.

Apart from the above, a set of auxiliary hypotheses (***Ha***) are tested in order to evaluate the performance of the STOPS framework in this comparative study that involves Japan and within the context of Natech risk communication. Assumptions that describe the relationships between the model variables were defined following the seminal work of Kim and Grunig (2011). First, citizens acknowledge the absence of chemical and Natech information as a problematic situation that

involves them personally, whilst there are significant constraints limiting their actions; all of these factors influence individuals' situational motivation in resolving the problem. Therefore, the perceived seriousness (***H_a1***) and personal connection with the Natech risk information deficiency meta-problem (***H_a2***) increase citizens' motivation to communicate, while the perceived obstacles reduce it (***H_a3***).

- ***H_a1***: Problem Recognition has a positive effect on Situational Motivation.
- ***H_a2***: Involvement Recognition has a positive effect on Situational Motivation.
- ***H_a3***: Constraint Recognition has a negative effect on Situational Motivation.

Furthermore, citizens are hypothesised to communicate in order to solve the presented Natech risk information deficiency issue; therefore, their situational motivation drives their communicative activeness (***H_a4***). Also, activated or improvised referent criteria are expected to increase communicative activeness in resolving the issue of Natech risk information deficiency (***H_a5***).

- ***H_a4***: Situational Motivation has a positive effect on Communicative Action in Problem-Solving.
- ***H_a5***: Referent Criteria have a positive effect on Communicative Action in Problem-Solving.

Finally, an increase in citizens' communicative activeness is expected to be linked with a rise in both the active and passive components of each of the three dimensions, namely information acquisition, selection and transmission. Thus, communicative action in problem solving is hypothesised to increase information forefending (***H_a6_a***), permitting (***H_a6_b***), forwarding (***H_a7_a***), sharing (***H_a7_b***), seeking (***H_a8_a***) and attending (***H_a8_b***).

- ***H_a6_a***: Communicative Action has a positive effect on Information Forefending.
- ***H_a6_b***: Communicative Action has a positive effect on Information Permitting.
- ***H_a7_a***: Communicative Action has a positive effect on Information Forwarding.
- ***H_a7_b***: Communicative Action has a positive effect on Information Sharing.
- ***H_a8_a***: Communicative Action has a positive effect on Information Seeking.
- ***H_a8_b***: Communicative Action has a positive effect on Information Attending.

3.3.2 Data Collection

The intention of this study is to investigate whether residents near prominent industrialised regions in Japan and S. Korea are motivated to communicate concerning Natech risk information disclosure, understand their communicative behaviour and identify the influencing factors. The objective is to apply STOPS as an interpretative framework in an attempt to analyse

the actual situation from the perspective of potentially affected communities, and compare cross-nationally citizen perceptions and communicative actions they engage in when trying to address the issue. This goal is best served by measuring directly the citizens' opinion through a household questionnaire survey.

Regarding the rationale behind the determination of the sample, the argument for understanding the actual situations should be highlighted once again. Chemical and Natech accident risks have the distinctive characteristic of being unevenly distributed over space. Even though the potential area of impact is admittedly vast, these types of risk are defined by the proximity to their source, chemical plants. Logically, properties and lives of individuals who reside and/or work closer to chemical plants are under greater risk. However, researchers have pointed out a similar gradient pattern in terms of public risk perception. This *'distance-decay principle'* describes the progressive 'discount' of individuals' concern about the risk the farther they perceive they are from its source (O'Neill et al., 2016; Venables et al., 2012). Furthermore, Yu et al. (2017) recently confirmed this effect in household risk perception about Natech accidents in Japan. Therefore, in an attempt to focus on citizens' perceptions who are actually under immediate risk from a chemical accident, households within a 2km radius from industrial parks were targeted primarily. The distance was chosen to reflect the 2km-radius evacuation order around the industrial installations during the Natech incident involving oil refinery fires and explosions triggered by the Great East Japan earthquake in 2011 (WHO, 2018).

Bearing in mind the above, this study focused on residential areas near prominent industrial parks in Japan and S. Korea. In both countries, major industrial parks that include facilities handling potentially hazardous materials are located along the eastern coastlines. Since tropical storms usually make landfall on the southeast Pacific coasts of these countries, this exposes such industrial parks to hydrometeorological hazards on a frequent basis. In fact, it is noteworthy that industrial parks like these have been in the path of destructive typhoons in the past. One recent example in Japan is Typhoon Jebi's impact on Osaka Bay in 2018; the consequent storm surge inflicted enormous damages and even flooded the Kansai airport (Hayashi et al., 2021). Similarly, several petrochemical industries were damaged and had to suspend operations due to rainfall-induced flooding caused by Typhoon Chaba (2016) at Ulsan's industrial park in S. Korea (Sang-soo, 2016). Moreover, recent studies characterised industrial parks in Ulsan and Gwangyang as among the most vulnerable in the S. Korea to typhoon-related hydrometeorological hazards (Ryu et al., 2016). Considering the general academic consensus over the increasing frequency of Natech accidents from tropical storms due to climate change (Luo, Cruz, & Tzioutzios, 2021; Cruz &

Krausmann, 2013), there is increased concern for such accidents at the industrial parks in Japan and S. Korea.

In order to collect data from individuals directly exposed to a potential Natech accident, this study targeted households located nearby large industrial parks. Two residential town districts were selected in Japan—specifically from the areas of Higashinada (Kobe) and Sakai-Senboku (Osaka)—and four town districts in S. Korea—namely from the areas of Yeosu, Suncheon, Gwangyang and Ulsan. For the Japanese sample, 2,630 questionnaires were distributed in total using post mail services (see Table A.1-1), which yielded *N*=330 responses (12.47% response rate). In comparison, previous studies with similar questionnaire distribution methods yielded slightly higher rates (14.3%) in Japan (Kotani & Yokomatsu, 2019) and lower (8.3%) in the United Kingdom (Eiser et al., 2009). The anonymity of the respondents was guaranteed through a town mail delivery system, which permitted the distribution of the surveys to all registered postal addresses within selected town districts. Participation was completely voluntary and without any financial incentive. The Korean sample (*N*=300; 100% response rate) was collected via an online survey employing the Tillion panel, the largest survey panel in the country, using locational restrictions. Participation was voluntary in this survey as well, but this time a small financial compensation in the form of promotional coupons was provided to participants. Finally, data collection was carried out from January 26 to March 8 in 2018 for the Japanese sample and from March 9 to March 18 in 2020 for the Korean.

The questionnaire instrument was comprised of 67 measurement items in total, including questions about the demographics. A seven-point Likert-type scale ranging from 1 = 'Strongly Disagree' to 7 = 'Strongly Agree' was used to code the responses. As a rule, at least three items per STOPS variable were included. Additionally, OPR factors were assessed through six items per variable by distinguishing between government institutions and industrial companies. The wording of the questions was based on measurement items tested and validated in previous applications of STOPS (Chen, Hung-Baesecke, & Kim, 2017; Kim et al., 2012) and suggested OPR measures (Grunig & Grunig, 2001; Grunig & Hon, 1999). Slight alterations were made to adjust the questions to the context of the study, when deemed necessary. Apart from STOPS and OPR measures, a number of questions about the perceived Natech accident severity and exposure, additional risk communication demotivators (e.g., impact on local economy) and social norms were included in order to better understand residents' concerns and challenges concerning Natech risk and the issue of information deficiency. Finally, demographic variables were comprised of gender, age, educational level, income, town district, nationality, household size and marital status.

According to Podsakoff et al. (2003), ensuring participants' anonymity is the most effective measure to combat common method biases. Suffice to say, no personal data were ever collected through this process that would permit one to trace back individual respondents. Besides the guaranteed anonymity, in order to further minimise participants' reluctancy to report delicate personal information—such as age or income—broad groups were provided as available options to select from instead of asking respondents to write down exact values. The questionnaire was reviewed by a panel of 30 experts specializing in disaster risk management. After minor modifications to the items other than the verified STOPS and OPR measures, the questionnaire was translated from English to Japanese and Korean by bilingual experts, and then checked for its accurate interpretation via *back translation*. Samples of the finalised versions are attached at the end of the Appendix (see Sections A.2 and A.3 for Japan and S. Korea respectively).

3.4 Analysis

3.4.1 Data Screening and Preparation

From the total 2,630 questionnaires mailed to all registered addresses in the selected districts in Japan, 330 households choose to cooperate and responded to the survey. After discarding two unanswered questionnaires a total of 328 replies (12.47% response rate) was amassed; 135 replies came from the Higashinada area and 193 from the Sakai-Senboku region. For the Korean sample, half of the responses came from Ulsan (150), 63 from Yeosu, 58 from Suncheon and 29 from Gwangyang (see Table A.1-1).

IBM's Statistical Package for Social Sciences (SPSS) version 27 was used for the following data preparation. The data screening process revealed one unengaged respondent in the Japanese sample (i.e., answered '7' throughout), whose answers were later discarded. The remaining Japanese sub-dataset with the 327 registered responses was then examined to determine whether there is an identifiable pattern for missing information. The Japanese sub-dataset passed Little's MCAR test, indicating that values are missing completely at random and therefore listwise deletion is among the suitable remedies (Hair et al., 2010). The method of listwise deletion resulted to a dataset of 317 responses, by dropping 10 respondents whose questionnaire completion rate did not reach 90% (suggested threshold). Next, the remaining responses were tested again using Little's MCAR test. The results justified data imputation. Residual missing data were imputed with the respective variable median; this technique is not expected to alter the variable mean (Hair et al., 2010), since the percentage of missing information per variable did not exceed 7.9% (suggested threshold 10%). This process did not deal with demographic variables at all, since their categorical nature does not allow for data imputation techniques. It should be noted that the Korean sub-dataset was originally complete, and therefore, no such data imputation process was needed.

Then, the Japanese and Korean sub-datasets were merged for the rest of the analysis. The complete dataset was examined for issues of normality; the purpose was to determine the suitability of STOPS and OPR items for the subsequent multivariate analysis. Table A.1-9 summarises the descriptive statistics for each questionnaire item. Problem Recognition items presented a considerable negative skewness, but within the threshold value of 2.20. Notably, items PR1 and PR2 exemplified quite high kurtosis with values of 2.15 and 2.56 respectively, but were safely below the threshold value of 3. Thus, all of the STOPS and OPR items were deemed satisfactorily normal for further multivariate analysis.

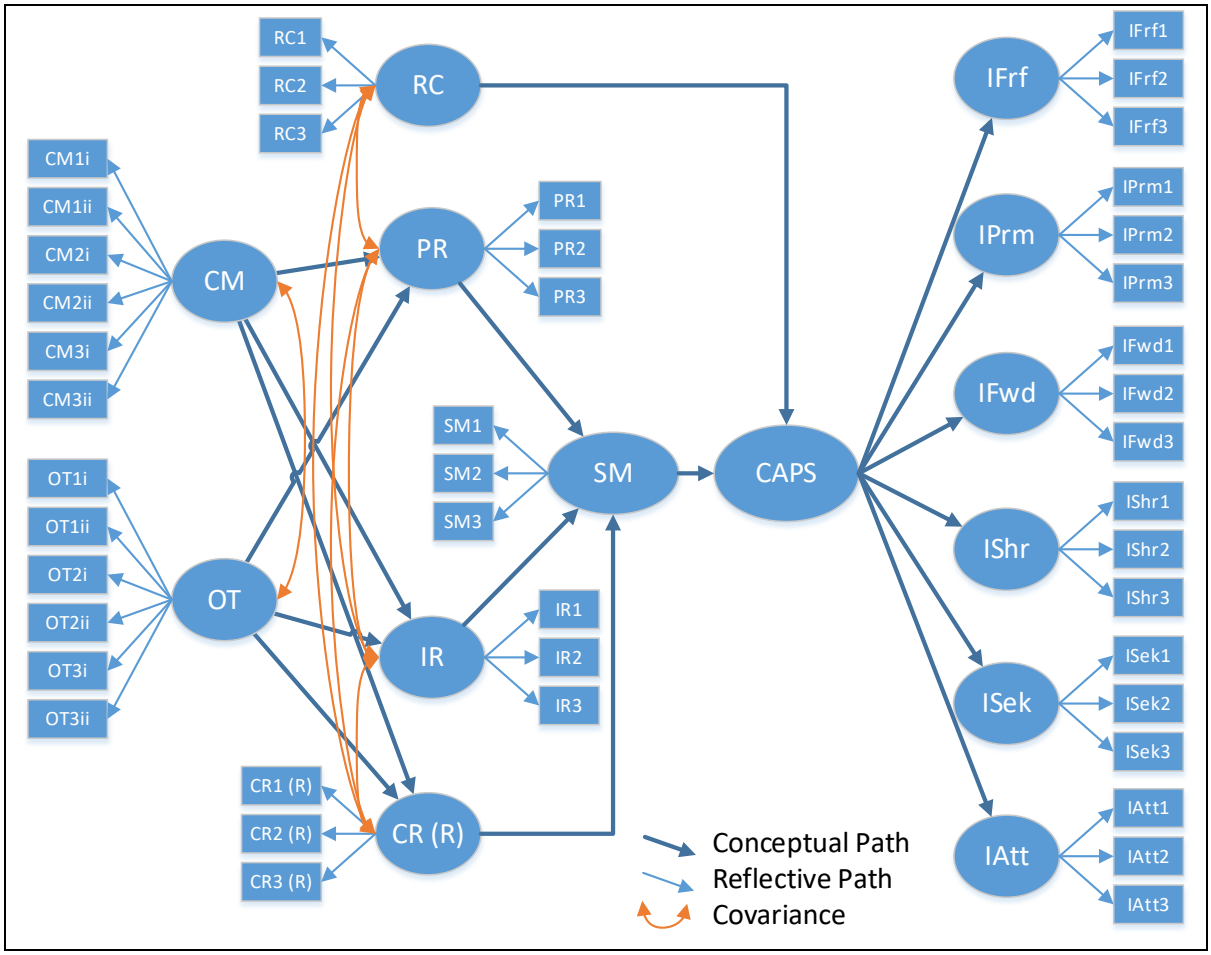
It should be highlighted that all three items for Constraint Recognition (CR) were reversed in the distributed questionnaire so as to remove part of the respondents' cognitive burden. These items reverse coded at this stage for the subsequent analyses—henceforth Constraint Recognition (CR) refers to the measurement as originally intended in STOPS (i.e., negative aspect).

3.4.2 Multivariate Analysis

The main part of the statistical analysis comprised of *Confirmatory Factor Analysis (CFA)* and *Structural Equation Modelling (SEM)*, two complementary modelling techniques that fall under the broader category of multivariate analysis; CFA is a method used for the analysis of theoretical constructs, while SEM involves regression or path analysis accommodating the simultaneous relationships between multiple dependent and independent variables (Hair et al., 2010). In this particular study, SEM was employed for strictly confirmatory purposes, in order to evaluate the STOPS model in the field of chemical and Natech risk communication and in the context of Japan. Therefore, no alternative models or configurations were proposed and tested. Furthermore, IBM's SPSS and Amos software packages versions 27 (both) were utilised for the respective analyses, employing maximum likelihood as the estimation method. Microsoft Office Visio 2013 was used for the model visualisations.

A two-step SEM approach was adopted (Kline, 2011). The first phase involved testing and determining the best items for each latent construct through a CFA. Low factor scores and/or largely insignificant loadings of observed variables on the latent constructs were the criteria according to which items were dropped from the model with the aim of identifying robust, valid and reliable item configurations. Figure 3.4-1 presents the initial latent model used in the SEM analysis, with the corresponding codes of the questionnaire items used in the survey (for reference see the Sample Questionnaires in the Appendix). It should be noted that sample sizes were sufficiently above the minimum suggested limit of $N>200$ for SEM analysis (Kline, 2011).

Figure 3.4-1 Initial Latent STOPS Structural Model



Source: Original work

In the next step, the measurement model was defined. Error covariances were introduced where necessary—but always respectful to the original theoretical reasoning of STOPS—based on Lagrange Multipliers in order to achieve model fit adequacy. The approach of Hu and Bentler (1999) for combined model validity criteria was followed, considering several commonly used indices, namely the Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Standardised Root Mean square Residual (SRMR). It must be noted that, the full latent model of the original STOPS conceptualisation was used for hypothesis testing and relationship interpretation, and only after model fit indices were deemed satisfactory. Effect sizes were interpreted based on the widely accepted thresholds proposed by Aiken et al. (1991).

The Multi-Group Analysis (MGA) method (Kline, 2011) was followed to conduct the cross-national comparison between the Japanese and Korean sample using the STOPS and OPR models. Prior to group comparison, tests were carried out to determine the models' invariance across groups (i.e., *configural validity*), check that the variables measure the same constructs across groups (i.e., *metric validity*) and to confirm that potential differences between groups can be

meaningfully interpreted (i.e., *scalar validity*) following the steps described by Milfont and Fischer (2010). Moderation effects between samples were investigated via a series of chi-square (χ^2) difference tests in which all but the model paths in question were constrained to be equal sequentially across groups.

Finally, outliers and influential cases in the results were examined by measuring Cook's Distance calculated from the regression of dependent variables on independent ones (Hair et al., 2010), using estimated scores for each latent variable generated through the respective SEM models.

3.4.3 Descriptive Analysis

The rest of the statistical analysis was based on basic—yet potent—descriptive statistics, that synthesised a comprehensive picture of the results and set the basis for the interpretation of the findings. Apart from the multivariate analysis conducted in order to establish the relationships among the factors and examine cross-national differences, a set of descriptive statistics were then calculated from the dataset in order to understand citizens' perceptions about the Natech risk and the associated information deficiency problem. In addition, descriptive statistics were used to compare the sample's demographic characteristics against the profile of the general population of the respective regions based on the latest available census data: the 2015 Population Census for Japan (Statistics Bureau, 2018) and the 2020 Population Census for S. Korea (Statistics Korea, 2020). Microsoft Office Excel 2016 was used predominantly for this type of analysis and the graphical representations of the results.

The hypotheses for cross-national differences in communicative behaviour were investigated by a series of independent samples t-tests between the two groups. The acceptance threshold for the 2-tailed significance test was set at the 95% confidence interval. Additionally, Cohen's distance (*Cohen's d*) was calculated to estimate and interpret effect sizes (Cohen, 1988).

Finally, a special reference should be made to the Public Segmentation technique used in this study. Although the canonical correlations procedure has been extensively used in the field of behavioural sciences, this study follows closely the much simpler segmentation method of summation introduced by Kim (2011). STOPS defines four types of publics based on the situational perception variables (i.e., problem, involvement and constraint recognition); these are *non-publics*, *latent publics*, *aware publics* and *active/activist publics*. The summation method proposes to use the midpoint of the item scale to recode effectively the situational perception characteristics as 'High' = 1 and 'Low' = 0, based on the mean scores from the items of each composite variable. In this study, the midpoint of the 7-point scale is 4. Therefore, individuals whose response averaged lower than or equal to 4 were coded as 'Low' (=0) for that particular variable. Conversely, if their answer

was 5 or higher, they were coded as 'High' (=1). Subsequent summation of the respective recoded characteristics provided the value based on which the classification was conducted: non-publics = 0, latent publics = 1, aware publics = 2 and active/activist publics = 3.

3.5 Results

3.5.1 Demographic Profile of Survey Respondents

The demographic profile of the survey respondents was drawn in respect to their gender, age, level of education, annual household income level, nationality, marital status, number of household members and, finally, whether there are children in the household. Detailed results are included in Table A.1-2 in the Appendix. The two samples' demographic characteristics are in turn compared against the average values of the closest respective administrative regions available based on the latest available data in Japan and S. Korea (Table A.1-3).

Out of the 328 Japanese participants, 187 (57.0%) were men and 135 (41.6%) women. The Japanese sample was dominated by male responders reaching a gender ratio of about 139 men for 100 women. In comparison, the Korean sample was more balanced in terms of gender ratio with a gender ratio of about 105 men for every 100 women. Out of the 300 respondents, 154 (51.3%) were male.

As far as age is concerned, 139 (42.4%) of the Japanese respondents were between 60 and 70 years old. The group of residents older than 75 years was the second largest (17.1%), followed closely by the ones between 50 and 59 years (16.5%). The number of respondents progressively declined for younger age groups, while there was only 1 respondent under the age of 19 (.3%). Naturally, this resulted to the very high mean age of around 61 years. The Korean sample in contrast was much younger with a mean age of 42 years. Remarkably, respondents' ages ranged from 20 to 59 years old, with the largest group being between 40 and 49 (29.6%).

In the Japanese sample, the two predominant categories in education were respondents who had finished high school (36%) and holders of a university degree (32.6%). Participants who attended a vocational school followed (14.6%), while holders of master's and doctoral degrees reached 8.2% together. Only 8 individuals had stopped after receiving elementary education. The Korean sample was starkly different. All respondents had completed at least high school education, with the vast majority holding a university degree (77%), followed by those holding a high school diploma (17.6%). Master's and PhD-holders were 5.3% combined.

Three broad categories were provided to participants to choose from in order to disclose their annual income level; despite such measures, 11% of the Japanese respondents did not share this information. The rest of the sample reflected the pattern observed in the Kinki prefecture with 118 households (36%) declaring an annual income of less than 3 million yen, 100 (30.5%) belonging

in the middle group and 74 (22.6%) having more than 6 million yen per year. Korean sample distribution was slightly different, since 45 out of the total 300 (15.0%) respondents belonged in the low-income group. The rest were almost equally divided between those with a middle-tier average monthly household income (44.3%) and those with more than 5 million won per month[11] (40.7%).

Both samples were quite homogenous in terms of nationality. There were only 2 respondents (.6%) from China and S. Korea in the Japanese sample, while there were no foreigners at all in the Korean sample.

Similarly, in both samples almost two thirds of the participating households were comprised of married couples (Japan: 66.4% and S. Korea: 70.7%). The second most frequent category was single households (Japan: 12.8% and S. Korea: 27.0%). In the Japanese group, widowed (8.84%) and divorced (6.71%) respondent categories followed. However, the Korean sample included only divorced respondents (2.3%).

Around two fifths of the Japanese sample were households with 2 members (37.8%) and one fifth with 3 members (21.7%). Single-member households followed closely behind (17.4%). Households with 4 or more members comprised the remaining (18.2%) of respondents. Korean households were generally larger. The second sample was dominated by 4-member households (34.7%), followed by 3-member households (28.7%) and couples (19.3%). Single-member households were only 24 out of 300 (8%). There were 28 households in total with 5 or more members (9.3%).

Finally, around two fifths of the sample were households with children (39.3%); adult-only households were 182 (55.5%). The situation is completely reversed in the Korean sample, in which almost two thirds consisted of households with children (63.3%). Merely 29 households were comprised of only adults (9.67%).

3.5.2 Structural Model Fit and Validity

During the first step of the modelling approach a confirmatory factor analysis was conducted in order to determine the reliability of the composite variables proposed by the STOPS and OPR frameworks. Table A.1-4 summarises the estimates from the initial model analysis. One item from Constraint Recognition, namely CR3, and one item from Information Seeking, particularly ISek3, significantly deteriorated construct validity and were subsequently dropped from the models as they demonstrated the poorest standardised factor loadings (*B*) (CR3: *B*=.41, *p*<.001 and ISek3: *B*=.48, *p*<.001 respectively) and inverse skewness compared to the remaining

[11] 5 million won per month is roughly equal to 6 million yen annually.

two observed items for each composite variable. The rest of the STOPS and OPR constructs were retained as initially proposed.

Table 3.5-1 ***Construct Validity Measures***

Variable	***Construct Reliability (CR)***	***Average Value Extracted (AVE)***	***Cronbach's α***
PR	.844	.643	.839
IR	.867	.686	.857
CR	.659	.513	.601
RC	.752	.526	.718
SM	.828	.618	.812
IFrf	.843	.643	.843
IPrm	.772	.539	.764
IFwd	.765	.52	.764
IShr	.859	.67	.857
ISek	.887	.798	.886
IAtt	.829	.618	.823
CAPS	.922	.665	– †
OT	.907	.623	.901
CM	.912	.638	.921
Criteria	**>.70**	**>.50**	**>.60**

Notes: Problem Recognition (PR), Involvement Recognition (IR), Constraint Recognition (CR), Referent Criteria (RC), Situational Motivation (SM), Information Forefending (IFrf), Information Sharing (IShr), Information Forwarding (IFwd), Information Seeking (ISek), Information Attending (IAtt), Information Permitting (IPrm), Communicative Action in Problem Solving (CAPS), Organisational Trust (OT) and Control Mutuality (CM).
Cells highlighted in red indicate values below respective thresholds. Criteria based on Fornell and Larcker (1981).
† CAPS constitutes a second order latent variable, and as such is not derived by observed questionnaire items from which Cronbach's a can be computed.

Source: Original work

A concise description of the convergent and discriminant validity measures for the finalised constructs of the STOPS and OPR models is presented in Table 3.5-1. The latent factors' composite reliability was examined through the estimated Construct Reliability index and Cronbach's α, while also the Average Value Extracted was taken into account. Between the first two measures, it should be noted that despite the popularity of Cronbach's α among researchers, Construct Reliability is a superior standard as it is more reliable and stricter. Nevertheless, findings were almost identical in both measures. All composite variables achieved very high construct reliability scores (i.e., >.718 for both indices), except for Constraint Recognition, whose construct reliability was just short of the threshold although its Cronbach's α was satisfactory. Given that there was already an item removed from this variable, no further remedies were available. As far as the AVE is concerned, all measures exhibited sufficient reliability as demonstrated through their scores. It should be noted that according to Malhotra and Dash (Malhotra & Dash, 2011, p. 702), AVE is considered a strict measure of reliability, and as evidenced all constructs achieved acceptable scores.

Table 3.5-2 ***Model Fit Indices***

Measure	***Cut-off Criteria***	***STOPS***	***OPR-Situational Variables***
χ^2	–	1984.604	1046.949
df	–	818	388
χ^2 / ***df***	Between 1 and 3 good	2.426	2.698
CFI	>.95 good, >.09 moderate	.901	.940
SRMR	<.08 good, <.10 moderate	.093†	.060†
RMSEA	<.06 good, <.10 moderate	.048†	.053†

Notes: Chi-square (χ^2), Degrees of Freedom (df), Comparative Fit Index (CFI), Standardised Root Mean Square Residual (SRMR) and Root Mean Square Error of Approximation (RMSEA).
Cells highlighted in green indicate exceptional values. Criteria based on Hu and Bentler (1999).
† Joint cut-off criteria according to Hu and Bentler (1999).

Source: Original work

The models' Goodness-of-Fit to the data was based on the joint criteria approach suggested by Hu and Bentler (1999). Their approach states that an empirical model is deemed strong if it achieves either CFI ≥ .96 *and* SRMR ≤ .10 or RMSEA ≤ .06 *and* SRMR ≤ .10. Evidently, the STOPS and OPR models satisfied the aforementioned thresholds (Table 3.5-2). However, considering that Hu and Bentler cut-off criteria use the stringent of thresholds, it can be argued that both models achieved adequate model fit based on commonly accepted criteria (Hair et al., 2010). It should be noted that the χ^2 index and its degrees of freedom (*df*) are typically sensitive to large sample sizes and particularly complex models (Kline, 2011), both of which cases apply in our models. Therefore, they are not considered as reliable indicators, despite their acceptable values. In sum, both structural models achieved a satisfactory model fit which warranted further interpretation of the corresponding causal models.

Additional tests were carried out to determine the models' invariance in order to conduct the comparison across samples. Initially, satisfactory scores in goodness-of-fit indices supported configural invariance of the unconstrained STOPS and OPR models. Next, paths were constrained to equal the factor coefficients to test for metric invariance, but invariance across samples for all parameters could not be supported for either model (χ^2 test: p<.001). After examining each individual path to determine the most problematic ones in each model, we identified the paths to be freely estimated across groups, thus establishing partial metric invariance adequate to proceed with our analyses (Hsiao & Lai, 2018). Likewise, scalar invariance was met partially due to the above reasons. After implementing the necessary modifications, both the STOPS and OPR nested models were rechecked for configural, metric and scalar invariance (Putnick & Bornstein, 2016). The nested models achieved satisfactory goodness-of-fit overall (*CFI*: .909, *SRMR*: .066 and *RMSEA*: .047) (see Table A.1-1).

Lastly, after mean values were computed based on the latent constructs of the model, Cook's Distance was examined so as to detect any hidden influential outliers in the sample. Each dependent variable was regressed on its respective set of independent ones based on model

conception. The maximum value across the results for all STOPS composite variables was .23; well below the threshold of 1.0 (Table A.1-8). In other words, no strongly influencing outliers were detected in the imputed factor scores that required special attention.

3.5.3 STOPS Structural Equation Models

First, the causal structural model for the STOPS variables were used to test the auxiliary hypotheses H_a1 through H_a8_b in order to validate the original model conceptualisation in the context of Japan and within the context of Natech risk communication. The results of the SEM analysis are presented in the following figures (Figure 3.5-1 for the Japanese and Figure 3.5-2 for Korean sample), while the detailed estimates can be found in Table A.1-5 of the Appendix. Three auxiliary hypotheses about the situational perception variables (H_a1 *through* H_a4), two about the situational motivation and the referent criteria (H_a4 *and* H_a5) and six about the CAPS variables (H_a6_a *through* H_a8_b) were tested, all of which were confirmed with large and statistically significant estimates. It should be underscored that all relationships followed the hypothesised patterns for both the Japanese and Korean sample, as discussed later in detail.

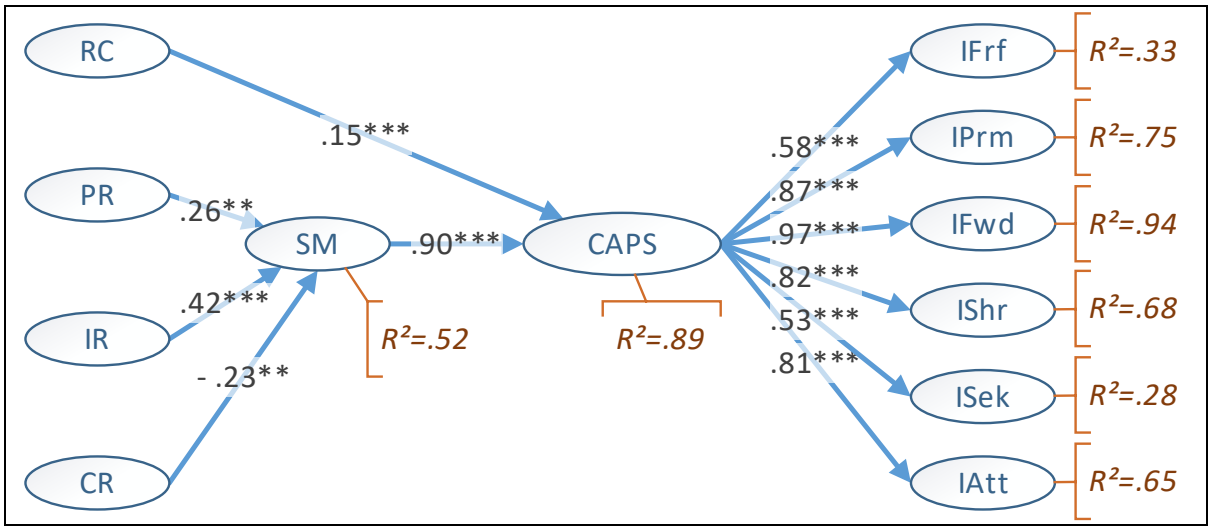
Moreover, as far as the abovementioned predictors' explanatory potency is concerned, the STOPS model exhibited exceptional results. In the case of the residents' situational motivation to resolve the problem, the three situational perception variables explained about 50% of the observed variance (Japan: R^2=.46 and S. Korea: R^2=.52). Explanatory power was even higher in the case of CAPS, exceeding 80% (Japan: R^2=.89 and S. Korea: R^2=.80) just from the influence of SM and RC for both samples. Similarly, interpretative power ranged from a modest 28% (R^2=.28) to a staggering 94% (R^2=.94) for the respective communicative actions. For the Korean sample the explanatory power was even stronger, ranging from 60% (R^2=.60) to 83% (R^2=.83).

Consistent with the STOPS narrative, Figure 3.5-1 shows that the more Japanese individuals recognised a problematic situation regarding the Natech risk information deficiency (PR), the more motivated they became (SM) to do something about the issue (***H_a1***) (coefficient B=.26, p<.01). Furthermore, the more Japanese residents perceived the Natech risk information deficiency affected their lives (IR), the higher their motivation (SM) was (***H_a2***). A statistically significant and relatively strong coefficient supported this (B=.42, p<.001). Additionally, the larger their perceived constraints in doing something about the issue (CR), the more their motivation (SM) diminished (***H_a3***). CR indeed exhibited a negative influence on SM (B=-.23, p<.01).

Moreover, residents were expected to channel their situational motivation (SM) to solving the problem by intensifying their communicative actions (CAPS) (***H_a4***). Indeed, SM proved to have a very strong impact on CAPS (B=.90, p<.001). Activated RC slightly enhanced individuals' CAPS for the Natech risk information deficiency issue (***H_a5***) (B=.15, p<.001). Complementary, all aspects of

communicative behaviour were positively affected by the residents' professed CAPS; specifically, information forefending (H_a6_a) (B=.58, p<.001), information permitting (H_a6_b) (B=.87, p<.001), information forwarding (H_a7_a) (B=.97, p<.001), information sharing (H_a7_b) (B=.82, p<.001), information seeking (H_a8_a) (B=.53, p<.001) and information attending (H_a8_b) (B=.81, p<.001).

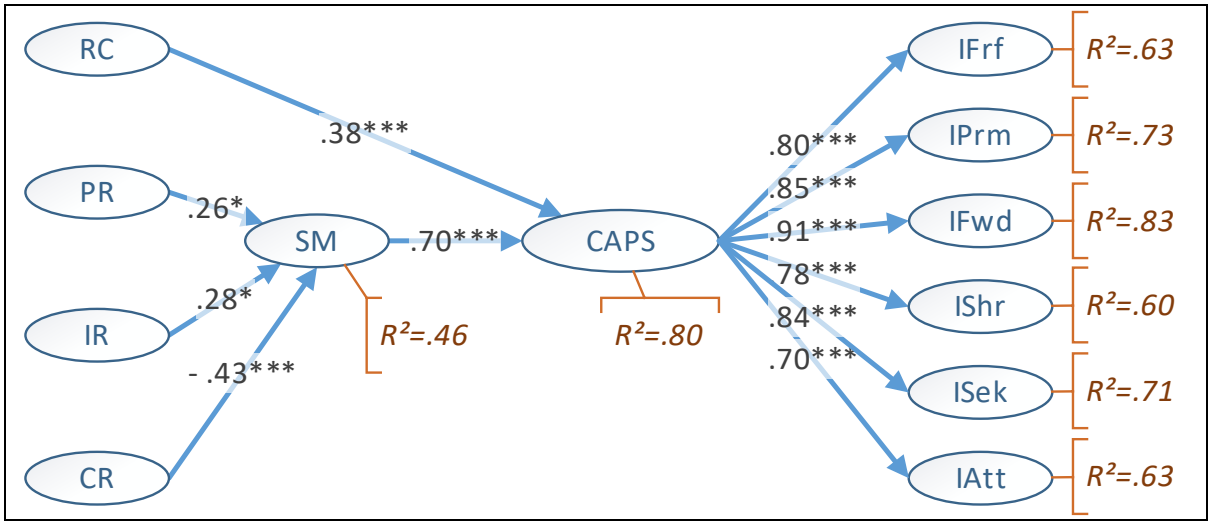
Figure 3.5-1 Summary Model Results from the STOPS Structural Model for Japan



Source: Original work

Likewise for the Korean sample (Figure 3.5-2), individuals became more motivated to communicate, as they recognised a problematic situation due to Natech risk information deficiency, perceived that this situation affected their everyday lives and believed that there are not significant constraints in resolving the issue (PR: B=.26, p<.05, IR: B=.28, p<.05 and CR: B=-.43, p<.001, respectively). Furthermore, Koreans' situational motivation along with available referent criteria increased their communicative activeness for the Natech risk information disclosure problem (SM: B=.70, p<.001 and RC: B=.38, p<.001). In turn, this enhanced communicative activeness positively affected information forefending (B=.80, p<.001), permitting (B=.85, p<.001), forwarding (B=.91, p<.001), sharing (B=.78, p<.001), seeking (B=.84, p<.001) and attending (B=.70, p<.001) for Korean citizens.

Figure 3.5-2 Summary Model Results from the STOPS Structural Model for Korea

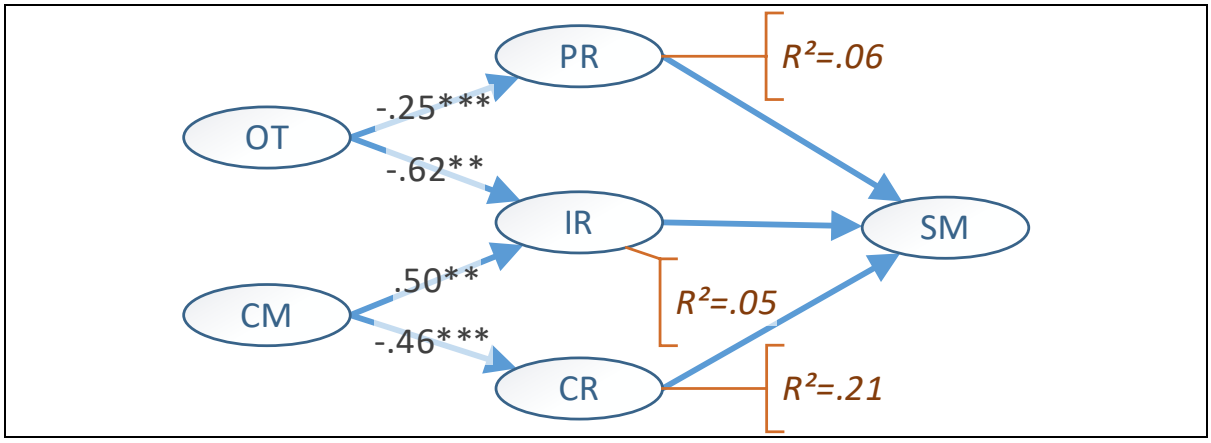


Source: Original work

3.5.4 OPR Structural Equation Models

The second structural model explored the linkages between measures of public-organisation relationship and situational perception variables pertaining to the problem of Natech risk information deficiency, as presented in the following figures. Table A.1-6 in the Appendix includes the detailed analysis results, based upon which hypotheses $H8_a$ through $H9_b$ were tested. We should remark here that the OPR measures (i.e., OT and CM) did not contribute substantially in explaining the variance observed in problem and involvement recognition across samples; explanatory power ranged only from 1% (R^2=.01) to 6% (R^2=.06). The exception was the influence of OPR factors on constraint recognition, which accounted for a modest 21% (R^2=.21) for the Japanese sample to a moderate 42% (R^2=.42) for the Korean.

Figure 3.5-3 Summary Model Results from the OPR-Situational Perception Structural Model for Japan



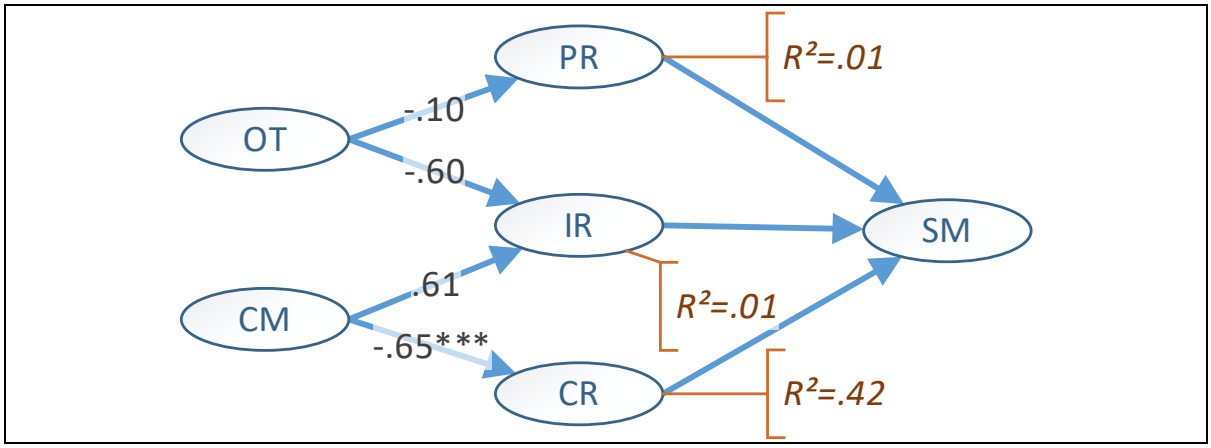
Source: Original work

Concerning the Japanese group (Figure 3.5-3), citizens' trust to government and businesses (OT) significantly lowered their concern about the lack of Natech risk information (PR) (*B*=-.25, *p*<.001) and even more so their perceived involvement (IR) in the presented problematic situation (*B*=-.62, *p*<.05). Thus, the corresponding hypotheses ***H8$_a$*** and ***H8$_b$*** were subsequently confirmed.

Furthermore, mutual control in decision-making (CM) demonstrated a slight decrease in terms of Japanese citizens' perceived barriers in doing something about the issue (CR). A moderate inverse correlation was observed (*B*=-.46, *p*<.001), which supported the original hypothesis ***H9$_b$***. Moreover, the hypothesized effect of CM on their immediate connection to the problem (IR) was also confirmed (*B*=.50, *p*<.05) (***H9$_a$***).

For the Korean sample (Figure 3.5-4), interestingly, path coefficients for the relationship between organisational trust (OT) and citizens' concern about Natech risk information deficiency (PR) (*B*=-.10, *n.s.*) and perceived involvement with this issue (IR) were statistically insignificant (*B*=-.60, *n.s.*). Therefore, the hypotheses ***H8$_a$*** and ***H8$_b$*** could not be supported, even though the expected directions of the relationships were observed.

Figure 3.5-4 Summary Model Results from the OPR-Situational Perception Structural Model for Korea



Source: Original work

Finally, perceived sharing of decision-making power (CM) demonstrated a strong negative effect on citizens' perceived constraints (CR). A statistically significant and large inverse correlation was observed (*B*=-.65, *p*<.001), which supported the original hypothesis ***H9$_b$*** also for the Korean sample. Nonetheless, the insignificant factor (*B*=.61, *n.s.*) of the expected effect of CM on involvement recognition (IR) could not corroborate our original claim (***H9$_a$***)—once again—despite confirming the predicted relationship direction.

3.5.5 Model Comparison

A series of χ^2 difference tests was conducted to test for any significant moderation effect between Japanese and Korean groups the structural equation models. The results for the STOPS and OPR models are summarised in the following tables.

Table 3.5-3 STOPS Model Comparison between Japan and S. Korea

Independent Var.	*Dependent Var.*	*DF*	C_{min}	χ^2 *test (p value)*	*Interpretation*
PR	SM	1	.001	.973	Similar
IR	SM	1	.264	.607	Similar
CR	SM	1	1.133	.287	Similar
RC	CAPS	1	2.637	.104	Similar
SM	CAPS	1	5.214	.022	Different
CAPS	IFrf	1	29.484	.000	Different
CAPS	IPrm	1	.000	.999	Similar
CAPS	IFwd	1	.215	.643	Similar
CAPS	IShr	1	.090	.764	Similar
CAPS	ISek	1	19.687	.000	Different
CAPS	IAtt	1	.987	.321	Similar

Notes: Problem Recognition (PR), Involvement Recognition (IR), Constraint Recognition (CR), Referent Criteria (RC), Situational Motivation (SM), Information Forefending (IFrf), Information Sharing (IShr), Information Forwarding (IFwd), Information Seeking (ISek), Information Attending (IAtt), Information Permitting (IPrm), Communicative Action in Problem Solving (CAPS).
Rows highlighted in green indicate structural paths with statistically significant differences between groups.

Source: Original work

As far as the STOPS model is concerned (Table 3.5-3), testing each individual path between the groups revealed that factor relationships are largely similar between the Japanese and Korean samples. The only statistically significant differences were observed in the influence of situational motivation (SM) on the communicative action (CAPS) ($p<.05$) and between communicative action and two out of the three active components of communicative behaviour, namely information forefending (IFrf) ($p<.001$) and seeking (ISek) ($p<.001$). These findings suggest that there are statistically significant differences in what elements drive communicative behaviour across the two respondent groups (i.e., moderation effects were observed for certain factors). In comparison to the Japanese group, Koreans' communicative activeness seems to depend less on situational motivation, while communicative activeness has a much stronger effect on proactive information acquisition and selection.

Table 3.5-4 OPR Model Comparison between Japan and S. Korea

Independent Var.	*Dependent Var.*	*DF*	C_{min}	χ^2 *test (p value)*	*Interpretation*
PR	SM	1	.05	.824	Similar
IR	SM	1	.214	.644	Similar
CR	SM	1	.021	.885	Similar
OT	PR	1	3.66	.056	Similar
OT	IR	1	.011	.915	Similar
CM	CR	1	16.042	.000	Different
CM	IR	1	0	.997	Similar

Notes: Problem Recognition (PR), Involvement Recognition (IR), Constraint Recognition (CR), Situational Motivation (SM), Organisational Trust (OT) and Control Mutuality (CM).
Rows highlighted in green indicate structural paths with statistically significant differences between groups.

Source: Original work

Furthermore, the results of χ^2 tests for the OPR structural models showed even less dissimilarity across the two groups (Table 3.5-4). Indeed, the only statistically significant moderation between Japanese and Koreans described the relationship between decision-making power (CM) and the perception of constraints (CR) ($p<.001$). All other path relationships were statistically indistinguishable.

3.6 Response Comparison and Public Segmentation

3.6.1 Response Comparison

Apart from the SEM and MGA analysis, descriptive analysis methods were employed in order to capitalise on the collected residents' responses in an attempt to approach the topic of Natech risk communication from the citizens' perspective in a comprehensive fashion. Scores for the composite latent variables were computed based on the results of the structural equation models. The questionnaire survey included certain additional items, such as Natech risk perception, further challenges and social norms, which shed light into various aspects of the subject and reveal valuable findings, as explained in detail next. These opinions were also coded on a Likert-type scale of 7 points, ranging from 1 = 'Strongly Disagree' to 7 = 'Strongly Agree'. A complete report of the computed statistic measures may be found in the Appendix (Table A.1-9). A series of independent samples t-tests were carried out to determine notable differences across Japanese and Koreans and help examine hypotheses *H1* through *H7*.

Table 3.6-1 Responses on Chemical and Natech Accident Risk

Variable	Aspect	Japan		S. Korea		t-Test sig. (2-tailed) - CI95%	Cohen' s *d (abs.)*
		Mean	Std. Dev.	Mean	Std. Dev.		
NTSev	Perceived Natech Severity	5.92	1.05	5.71	.95	.009	.2120
NTLik	Perceived Natech Likelihood	5.70	1.15	5.82	.95	.161	.1132
NTResp	Perceived Response Efficacy	2.75	1.55	4.00	1.51	.000	.8204
NTWith	Withholding Natech Information	4.71	1.35	5.17	1.15	.000	.3690

Japan: N=317; Korea: N=300
Rows highlighted in green indicate statistically significant differences between groups.

Source: Original work

A crucial precondition for residents to recognise a problematic situation stemming from the lack of risk information is the realisation of the chemical and Natech accident threat itself. Table 3.6-1 presents the results of the questions targeted at capturing exactly that. Generally, households from both samples expressed highly their concern in facing a potential chemical accident triggered by a natural hazard (*NTSev*: μ=5.92 and μ=5.71). However, there was also a statistically significant difference between the two groups (p<.01, d=.2120), as Japanese perceived Natech risk to be more severe. As far as the perceived probability is concerned, Japanese and Korean citizens evaluated equally high their potential exposure to such an accident (*NTLik*: μ=5.70 and μ=5.82). A stark difference was observed between Japanese and Korean households, however, when asked whether they have sufficient knowledge to respond appropriately to such scenarios (*NTResp*); Japanese (μ=2.75) scored significantly lower (p<.001, d=.8204) than Koreans (μ=4.00) in this regard. Remarkably, Korean residents tend to believe the possibility that local governments and industries might withhold information about the actual chemical risk from the public (*NTWith*: μ=5.17) considerably (p<.001, d=.3690) more than Japanese (μ=4.71).

As far as the meta-problem of Natech risk information deficiency is concerned (Table 3.6-2), Japanese and Korean respondents agreed on its great importance for them (*PR*: μ=5.89 and μ=5.74) equally. Furthermore, their perception of this problem affecting their everyday lives directly was measured to be equally high for both groups (*IR*: μ=5.21 and μ=5.31). Interestingly, perceived constraints that limited citizens from improving the problematic situation were considerably lower for Koreans (*CR*: μ=4.12) compared to Japanese (μ=4.67). This observed discrepancy was statistically significant with a moderate effect size (p<.001, d=.4422).

Table 3.6-2 Responses on STOPS Measures

Variable	Aspect	Japan		S. Korea		t-Test sig. (2-tailed) - CI95%	Cohen' s *d (abs.)*
		Mean	Std. Dev.	Mean	Std. Dev.		
PR	Problem Recognition	5.89	1.07	5.74	.84	.053	.1564
IR	Involvement Recognition	5.21	1.30	5.31	.97	.294	.0847
CR	Constraint Recognition	4.67	1.17	4.12	1.34	.000	.4422
RC	Referent Criteria	3.37	1.11	4.12	1.19	.000	.6457
SM	Situational Motivation	4.43	1.26	4.69	1.08	.005	.2261
IFrf	Information Forefending	2.66	1.20	3.61	1.36	.000	.7353
IPrm	Information Permitting	4.83	1.13	4.58	1.06	.005	.2293
IFwd	Information Forwarding	3.73	1.16	4.32	1.13	.000	.5152
IShr	Information Sharing	4.02	1.30	4.56	1.05	.000	.4581
ISek	Information Seeking	3.28	1.24	3.89	1.32	.000	.4740
IAtt	Information Attending	4.92	1.18	4.87	1.03	.560	.0470

Japan: N=317; Korea: N=300
Rows highlighted in green indicate statistically significant differences between groups.

Source: Original work

The rest of the differences were compared in order to examine our set hypotheses. Korean citizens expressed increased curiosity and desire to learn more about the problem (*SM*: μ=4.69) compared to Japanese (μ=4.43). Although the difference was small, it was statistically significant (p<.01, d=.2261), and thus evidenced our original claim (***H1***). Similarly, Japanese residents did not have as many readily available ideas on how the issue of Natech risk information deficiency could be addressed (*RC*: μ=3.37) in comparison to Koreans (μ=4.12). Also, this difference was statistically significant and had a great effect size (p<.001, d=.6457) strongly supporting our argument (***H2***).

Comparing the communicative behaviour citizens assume concerning the Natech risk information deficiency, Japanese seem to have not expended much effort in finding information or selecting trusted sources for their updates on the matter (*IFrf*: μ=2.66) In contrast, Koreans—confirming our hypothesis (***H3a***)—were considerably more active (p<.001, d=.7353) in terms of information forefending (μ=3.61). On the contrary, Japanese residents reported that they are more eager than Koreans to listen to various sources that talk about the problem in their attempt to better comprehend the situation (*IPrm*: μ=4.83 and μ=4.58). Although, the size effect was small, this statistically significant difference (p<.001, d=.2293) refutes our corresponding hypothesis (***H3b***).

In addition, Koreans' information forwarding behaviour measured higher than the Japanese (*IFwd*: μ=3.73 and μ=4.32), indicating that they were markedly more eager (p<.001, d=.5152) than Japanese to inform loved ones and convince others about resolving the issue. So, our claim was confirmed (***H4a***). In relative moderation Japanese also reactively share information and their opinions, when asked to do so (*IShr*: μ=4.02). They scored remarkably less (p<.001, d=.4581) than Koreans (μ=4.56) in this respect as well, thus supporting our hypothesis (***H4b***).

Finally, Japanese seemed comparative less active in searching for information related to the problem (*ISek*: μ=3.28) compared to the Korean sample (μ=3.89). These results provided a statistically significant and moderately strong support (p<.001, d=.4740) for the respective hypothesis (***H5$_a$***). No statistical difference could be detected between the scores for information attending between Japanese and Korean and thus we could not confirm our initial claim (***H5$_b$***). Scores were quite high for both groups samples (*IAtt*: μ=4.92 and μ=4.87), indicating citizens' general interest in obtaining any information that is available in their everyday environment.

Table 3.6-3 Responses on Organisation-Public Relationship Measures and Additional Constraints

Variable	Aspect	Japan		S. Korea		t-Test sig. (2-tailed) - CI95%	Cohen' s *d* (*abs.*)
		Mean	Std. Dev.	Mean	Std. Dev.		
OT	Organisational Trust	3.41	1.32	4.23	1.02	.000	.6854
CM	Control Mutuality	3.16	1.24	3.82	1.14	.000	.5505
JKN1	Social Discomfort	3.05	1.64	3.94	1.71	.000	.5322
JKN2	Expected Citizen Participation in Decision-making	4.55	1.56	4.33	1.65	.096	.1343
JKN3	Government Trust about Info Access	3.22	1.61	4.65	1.42	.000	.9397
OC1	Perceived Impact on Property Values	5.63	1.11	5.42	1.15	.021	.1866
OC2	Perceived Impact on Local Economy	4.96	1.37	5.21	1.23	.017	.1923
OC3	Lack of Chemical Info	5.56	1.18	5.54	1.05	.838	.0164
Japan: N=317; Korea: N=300 *Rows highlighted in green indicate statistically significant differences between groups.*							

Source: Original work

In terms of the quality of their relationships with government institutions and industrial companies (Table 3.6-3), the survey results seemed to confirm our original hypotheses. Indeed, Japanese households seemed to be rather distrusting of such organisations compared to Koreans (*OT*: μ=3.41 and μ=4.23). This demonstrated essentially a sizeable and statistically significant difference (p<.001, d=.6854) that supported our argument (***H6***). A similar pattern was observed with regard to decision-making power-sharing (*CM*). Japanese respondents reported lower levels of perceived control mutuality than Koreans (*CM*: μ=3.16 and μ=3.82). The discrepancy was large and significant, and so strongly supported our claim (***H7***).

Supplementary questions were asked in order to explore citizens' perceptions regarding specific challenges pertaining to social norms and risk communication; the survey results presented a very interesting picture (Table 3.6-3). The perceived negative consequences from Natech risk information disclosure on property values were considered as more important for Japanese than for Koreans (*OC1*: μ=5.63 and μ=5.42). However, the inverse was true for the

perceived impact on the local economy, for which Koreans seemed to be more concerned (*OC2*: μ=4.69 and μ=5.21). Although effect sizes were small for both of the above differences, they were indeed borderline statistically different (p<.05, d=.1866 and p<.05, d=.1923). Additionally, both Japanese and Koreans agreed that the lack of publicly available information about the involved chemical risk presents an important limitation for them (*OC3*: μ=5.56 and μ=5.54).

Furthermore, Japanese citizens seemed to believe that asking about chemical and Natech information would not be perceived as a disturbance in the local community (*JKN1*: μ=3.05) while Koreans were more indifferent towards this statement (μ=3.94). Nonetheless, this discrepancy was considerable and statistically significant (p<.001, d=.5322). Moreover, Japanese and Korean respondents felt rather excluded from the decision-making processes concerning chemical risk management (*JKN2*: μ=4.55 and μ=4.33); there was no observable difference between samples. Finally, there was an enormous and statistically significant discrepancy concerning the last aspect (p<.001, d=.9397). Koreans seemed considerably more trusting of their government about the way access to chemical risk information is handled (*JKN3*: μ=4.65). In contrast, the score for the Japanese sample was well below the midpoint of the scale (μ=3.22).

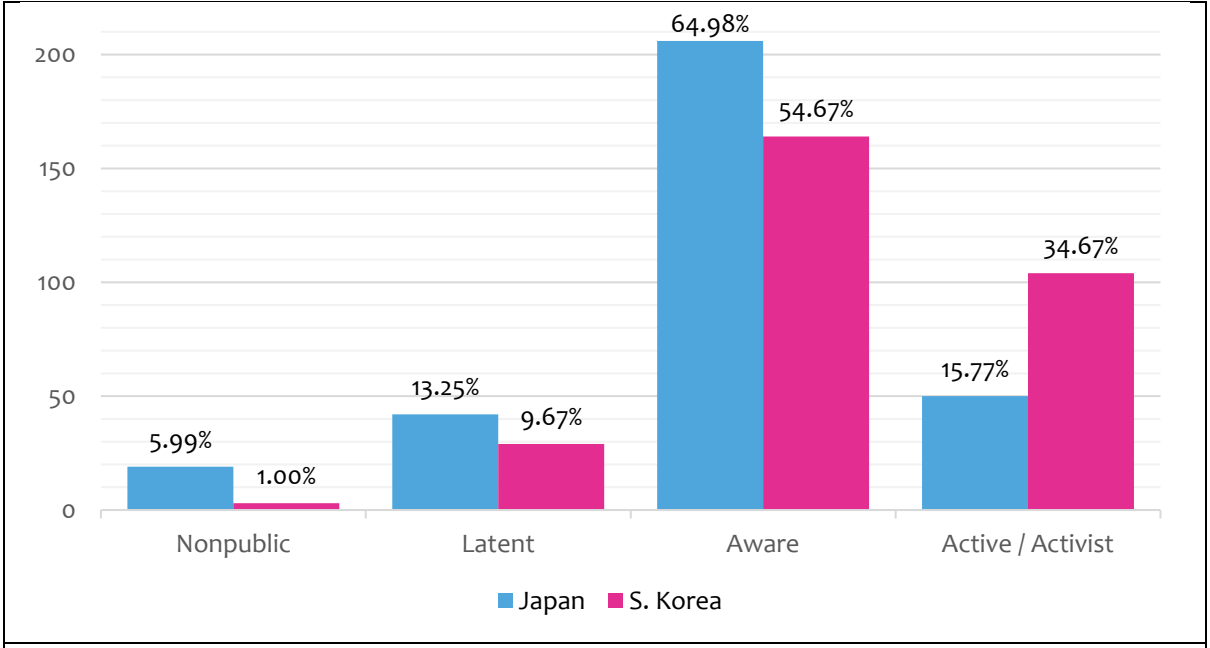
3.6.2 Public Segmentation

Pubic segmentation lies at the heart of situational theories offering a more detailed understanding of the diverse publics and the communicative behaviour they assume in their attempt to resolve a problematic situation. In this particular study, the segmentation method of summation was employed in order to delineate the communicative profile of non-publics, latent publics, aware and active/activist publics pertaining to the problem of Natech risk information deficiency. Respondents' situational perception characteristics, namely problem, involvement and constraint recognition, were recoded into 'High' and 'Low' and then added to categorise each individual into one of the four publics. The results of this process are presented in Figure 3.6-1.

Out of the 317 survey respondents from Japan, 19 (5.99%) fall into the first category, i.e., non-publics. They do not seem to perceive the presented situation stemming from the absence of publicly available Natech risk information as a problem. Of course, since they do not recognise the problem, their perceived involvement with it and any obstacles that limit their actions are non-existent, as well. 42 respondents (13.25%) seem to perceive this Natech risk information deficiency as a problem through its consequences in their lives, however they might not have fully acknowledged it yet. They comprise a latent public. Almost two thirds of the sample belong to an aware public. 206 respondents (64.98%) perceive this Natech risk information deficiency as a significant issue that motivates them to do something about resolving it, although they have not taken any actions still. Finally, 50 respondents (15.77%) exhibited the situational perception

characteristics of an active/activist public. They demonstrated high problem and involvement recognition, whilst finding only obstacles they can overcome relatively easily (i.e., low constraint recognition).

Figure 3.6-1 Public Segmentation for Natech Risk Information Deficiency Problem in Japan and S. Korea



Japan: N=317; Korea: N=300

Source: Original work

A similar trend was observed in the Korean sample as well. Only three (1.00%) out of the 300 total respondents were categorised as a non-public, that does not perceive a meta-problem of Natech risk information deficiency. Next, 29 respondents (9.67%) notice this problem but have not fully recognised it yet (i.e., latent public). More than half of the Korean sample comprises an aware public with 164 respondents (54.67%) perceiving this lack of Natech risk information disclosure as an important issue that they wish to resolve (i.e., aware public). More than one third of the households seemed to fall into the active/activist public category—more than double from the Japanese sample. These 104 Korean respondents (34.67%) demonstrated high problem and involvement recognition, whilst identifying only a few limiting barriers that would hinder their personal actions to deal with the situation.

3.7 Discussion

3.7.1 Demographic Profile

A detailed examination of the respondents' sociodemographic profiles revealed notable differences between the Japanese and Korean samples in terms of age, educational level, household income and size. While gender ratios were comparable across the two groups, the Japanese sample was on average about 19 years older. Moreover, Korean respondents had

attained a higher level of education and reported a slightly higher annual household income comparatively to Japanese on average. Additionally, the slightly larger household size on average, along with the marital status and the presence of children in the household, suggested that the Korean sample included more family households overall. Indeed, single-member households were rarer in the Korean group in comparison to the Japanese.

The above observations about the sociodemographic features are certainly not unrelated with each other and actually hint toward the character of the town districts the data were collected from, as well as the methods employed. For instance, the overrepresentation of males in the Japanese sample may be linked to the patriarchal household structure in Japan. It is probable that the household representatives that took the responsibility of replying to an anonymous survey were predominantly men. Furthermore, the average age of the Japanese sample was quite elevated. One possible reason for this could be that residents who decided to participate in this—admittedly long and without any concrete incentive—survey, actually had simply more free time to spend. After all, the groups above the age of 60 years, which also coincides with the retirement age in Japan, happened to be the largest.

In addition, certain residential districts selected for the Japanese sampling were comprised of old, traditional small houses, typically lived-in by their owners. Families may look elsewhere for accommodation in search for newer apartment buildings, larger spaces and so forth compared to single-member households, like retirees. Thus, areas such as the Takaishi city's case may have been overrepresented in the overall Japanese sample and contributed to this difference. Smaller household sizes of course correlate positively with lower household incomes. On the other hand, the online-based panel survey carried out in S. Korea probably further exacerbated the age discrepancy between the two samples. Younger generations are usually more confident in using computer technologies, and thus conducting an online survey that employs no age-related strata for sampling, likely decreased the average age of Korean respondents in our study.

But, perhaps, these are rather superficial reasons, and there exists an association between the topic of the survey and the observed sociodemographic profile. An emerging pattern is the underrepresentation of younger, single (never married) and childless households in the survey. On the one hand, it could be that households from these categories were scarce to begin with in the selected districts. On the other hand, younger individuals have been associated with lower degrees of concern about nuclear and Natech risk (Yu, Cruz, & Hokugo, 2017; Sjöberg, 2004). There is a possibility that single households with no children are also of a similar low concern mindset about Natech risk. However, previous studies were inconclusive on that front (Yu, Cruz, & Hokugo, 2017). There is no strong supporting evidence in this or previous studies and therefore there can only be

speculation about it, but perhaps these younger, single and childless households did not participate in this survey due to the level of priority they assign in contributing without immediate profit to a study about an issue that is remotely linked to their everyday lives. In other words, they chose not to spend time in answering an anonymous questionnaire about potential chemical and Natech accidents, because they deem the subject of low importance.

Contemplating potential effects of the observed sample differences in sociodemographic characteristics, we speculate the following based on past risk perception research (Sund, Svensson, & Andersson, 2017; Savage, 1993). Given the research evidence suggesting that males are likely to underestimate risks in various contexts, perhaps, the subsequent Natech risk information deficiency meta-problem is not viewed as salient, which in turn decreases motivation to communicate. In addition, older citizens have been exposed to the chemical risk and faced the associated meta-problem for longer. So, they might recognise it as more severe and persistent. Similarly, a higher educational level may be associated with increased Natech risk awareness and perceived severity of the meta-problem of information deficiency. Additionally, more household members equal more individuals potentially exposed to the accident risk, and so, the perceived situation about the risk information deficiency may be regarded as more severe by individuals. In contrast, higher household incomes means that more resources are available to solve the problematic situation; thus, the perceived severity of the meta-problem may be less pronounced. Finally, having (co-)dependent household members, such as spouse and/or children, may increase concerns about the meta-problem as the underlying Natech risk seems more threatening. In any case, the potential influence from sociodemographic factors on individuals' perceptions about Natech risk information disclosure is an important research direction future studies are invited to investigate.

Different data collection strategies may be employed in future surveys to address these issues. A stratified random sampling method based on sociodemographic criteria (e.g., gender, age, education, income, and so forth) would be more appropriate when pursuing a more accurate representation of the broader population in the samples. However, in that case geographical restrictions may have to be reassessed. In view of keeping the required anonymity involved in data collection while targeting households near industrial parks, providing reward incentives for respondents is also expected to increase the response rate. Besides, there are very few studies which have focused on chemical—and particularly Natech—risk communication in Japan, therefore the findings are important. In any case the intention of this study was not to produce generalisable results for the whole of Japan, but rather focus on the risk perceptions and communicative behaviour of residents around industrial parks in Osaka Bay.

3.7.2 STOPS Evaluation

Following the process of SEM analysis, it is indispensable to assess the models' validity and goodness-of-fit to the date before continuing on to interpret the extracted results. However, in this particular study, evaluating the conceptual model's explanatory capability in respect to the collected data received the importance of a core research endeavour, since the theoretical framework of STOPS has never been applied in Natech risk communication or in the sociocultural context of Japan. Fortunately, the results were mostly satisfying.

First and foremost, all of the expected relationships between the STOPS variables have been confirmed for both the Japanese and Korean samples. This was confirmed even for the relationship of problem recognition (PR) with situational motivation (SM), despite the arguably high kurtosis and negative skewness of the composite variable and two of its measurement items (namely PR1 and PR2). Problem recognition was a statistically significant predictor for situational motivation for both samples. A probable explanation for the underlying issue might be the very topic of this study. Chemical and thus Natech accident risk is characterised by high levels of dread in public perceptions (Sheppard, Janoske, & Liu, 2012; Slovic & Weber, 2002). In this context, asking citizens about the perceived severity of a problematic situation that is associated with a dreadful risk is expected to receive increased significance; *ergo* the observed high kurtosis and negative skewness of problem recognition. Interestingly, effects on SM were still evidenced through our analysis, in spite of the relatively small variation of PR that could have presented challenges for a technique, such as SEM, that relies on the analysis of sample variance to infer statistically significant relationships between variables. In summary, all auxiliary hypotheses H_a1 through H_a8_b which describe STOPS's original theoretical framework were strongly supported.

Additionally, the viability of the structural model itself has been established under the strictest of measures, the joint criteria approach of Hu and Bentler (1999). Even more impressive, this has been accomplished using a dataset that was not intended to test the theory *per se*, but rather apply its interpretative framework in order to assess citizens' communicative behaviour towards Natech risk communication from a cross-national perspective. It can be argued that the employed sampling strategy was far from optimal for this end. Even the different data collection methods (post mail in Japan versus online survey in S. Korea) may have created additional challenges. Alternative approaches could have included an online nationwide random panel of participants, following the example of previous studies that looked into publics' communicative behaviours in more detail (e.g. Chen, Hung-Baesecke, & Kim, 2017; Kim et al., 2012), or stratified sample from the respective regions that would guarantee sociodemographic representation of the populations. Resource limitations aside, the purpose of this study was to understand the

perceptions and challenges of residents, who are likely to be directly impacted in a chemical and Natech accident scenario; spatial proximity to industrial installations is a key issue here.

The distance-decay principle has been found to affect individuals' risk perception (O'Neill et al., 2016; Venables et al., 2012) and was recently confirmed in the Japanese context as well (Yu, Cruz, & Hokugo, 2017). Hence, selecting districts near industrial sites in Osaka Bay (Japan) and Ulsan, Yeosu, Suncheon and Gwangyang (S. Korea) arguably introduces a kind of bias. In this regard, it is not surprising that the majority of participants perceived Natech risk to be a severe threat and the information deficiency seemed to an important meta-problem for them. Even so, it is interesting to report that their sense of involvement with the meta-problem and being constrained in doing something still varied considerably across respondents. STOPS performed exceptionally well in explaining large portions of the observations' variance overall, even under such extreme circumstances of 'partial' sampling. Besides, a relatively radical approach in testing the limits of a theory dictates one to do so at the boundary conditions in purpose of stressing it under circumstances which would 'break' normal rules; a tactic that particularly applies in Disaster Science disciplines due to their nature (Mendonça, 2018).

Accordingly, OPR measures performed equally well, achieving decent construct reliability and model fit. The structural model of OPR and situational perception variables demonstrated high goodness-of-fit to both the Japanese and Korean sample, fulfilling the strict criteria of Hu and Bentler's (1999). All of the hypothesised relationships were confirmed for the Japanese sample ($H8_a$ through $H9_b$), but only the effect of control mutuality (CM) on constraint recognition (CR) ($H9_b$) was supported for the Korean group. Considering the synergistic effect of combining OPR assessment measures with the STOPS components in order to delineate a more comprehensive description of the factors that influence citizens' perceptions about Natech risk communication probably outweigh this minor discrepancy.

3.7.3 Research Findings

The main objective of this study was to explore the differences in the communicative behaviour of citizens in Japan and S. Korea concerning the issue of Natech risk information disclosure. From a situational theory perspective, it becomes evident that both Japanese and Korean citizens indeed *'stop to think about what to do'* (Grunig, 1997 in Kim & Krishna, 2014, p. 85) concerning the Natech risk information deficiency meta-problem, which in turn drives them to engage in communicative action to solve it. A careful review of the research findings seems to support this claim across the two groups (i.e., elevated problem and involvement recognition, low constraint recognition and relatively high situational motivation), and further brings to light

valuable insights about their communicative behaviour patterns and perceived challenges towards this issue.

Our study revealed an increased public concern for chemical and Natech risks as predicted based on risk communication and perception literature (Sheppard, Janoske, & Liu, 2012; Slovic & Weber, 2002). As typical high-impact/low probability technological risks (Masys et al., 2014), they seem to follow the risk perception trends of similar chemical and nuclear accidents: high unfamiliarity, increased dread and with long-term consequences (Slovic & Weber, 2002). Moreover, households in Japan and S. Korea characterised Natech accident scenarios as very likely and severe, recognising potential consequences to their communities. However, Japanese respondents' perceived Natech risk severity was slightly increased compared to the Korean sample. This observation aligns with past risk perception research suggesting that Koreans had a lower risk perception for chemical accidents (Zhai & Suzuki, 2009). From our perspective, the higher Natech risk perception observed in Japan may be related to the fact that Natech accidents are more likely to occur due to the comparatively increased earthquake and tsunami risk (Park & Cruz, 2022). Given that Japanese residents have become more accustomed to frequent and intense earthquakes in contrast to Koreans, it is plausible that they find chemical accidents triggered by them to be also more likely to happen.

More interesting, however, is the discovery of a notable awareness regarding the perceived *meta-problem* of information deficiency that stems from this situation. The lack of Natech risk information is acknowledged by both Japanese and Korean residents as a problematic situation they are concerned about, and affects their personal lives to a certain degree. Nonetheless, Japanese citizens admitted their inability to respond to potential Natech accident scenarios due to insufficient information. This finding is reasonable since the Japanese chemical risk regulatory framework does not oblige local governments or industrial companies to disclose contingency and emergency response plans to the local community. On the other hand, Koreans reported a significantly higher perceived self-efficacy for such scenarios. This is most likely attributed to the recent change in the Korean chemical risk management legislation that has made mandatory the notification of Hazard Control Plans—which include chemical emergency response plans among others—to the public (see Act No. 14532, 2018, article 23).

It should be noted, however, that Japanese and Koreans even more so expressed their scepticism towards governments and businesses withholding information about the actual chemical risk in industrial facilities. Of course, publics nowadays are not as ignorant of trade secrecy and civic safety reasons that are often used by organisation as a pretext to disclose the

bear minimum amount of information (Kinchy & Schaffer, 2018). This is a plausible explanation based on our findings.

According to STOPS, situational perception of the significance of the problem, the personal connection with it and the complications that limit one's ability to resolve it drive their individual motivation to take communicative action. This narrative seems to explain our observations for both groups based on the SEM analysis. For the Japanese case, we found that the degree to which individuals perceived their involvement with the situation was the most influential in shaping this situational motivation for problem-solving, followed by problem and constraint recognition. These three factors accounted for an impressive 52% of the observed households' motivation to do something about the Natech risk information deficiency issue. In comparison, perceiving only limited insurmountable obstacles seems to be the main factor for the Korean sample's situational motivation, with personal involvement and problem severity perceptions following. Together these aspects explained a decent 46% of the problem-solving motivation for Koreans overall. Nonetheless, our analysis did not reveal any statistically significant differences between the two concerning these relationships.

Moreover, high situational motivation in turn is the leading factor for citizens' communicative activation in both groups. Along with referent criteria, situational motivation accounted for 89% of the observed communicative activeness in Japan and 80% in Korea. Referent criteria for the Natech risk information deficiency issue contribute by a smaller amount to communicative activeness in both cases. For the Japanese sample these probably come in the form of subjective judgmental rules and expectations rather than past experiences, as evidenced by the absence of a concrete idea for resolution. Although no significant discrepancy was evidenced across groups, referent criteria exerted stronger influence on communicative action. However, we observed a statistically significant difference between groups concerning the relationship of situational motivation and communicative actions. According to our findings, Koreans' communicative behaviour seems to be influenced to a lesser degree by situational motivation in comparison. Judging by the increased influence referent criteria exert on Koreans' communicative action, we would argue that chemical risk communication efforts (see Act No. 14532, 2018, article 23) may have provided ideas for how Natech risk as well as the associated meta-problem of information deficiency can be effectively managed.

Looking in more depth this citizens' communicative behaviour, we observed differences across the two groups concerning the relationships between communicative activeness and information forefending and seeking. Despite the overall strong influence of problem-solving communicative action on all aspects for both groups, Japanese seemed comparatively less likely

to search for and select information. This is an interesting finding because, on the one hand, Koreans are culturally more 'feminine' than Japanese (Hofstede, Hofstede, & Minkov, 2010). We can speculate that caring for others within the society and considering quality of life issues may be an influencing factor that increases communicative activeness. In this sense, Koreans may feel a stronger urge to actively search for risk information (i.e., seeking) and finding trustworthy and useful information sources (i.e., forefending) compared to Japanese. On the other hand, it is possible that the Korean governments risk communication efforts have positively contributed to activating the audience. Being 'exposed' to the broader public discourse about chemical risk management thanks to the information disclosure provisions in Korean legislation, may have made citizens more eager to actively search for information about it, seeing that there are not as many obstacles to access said information (see 'Comprehensive Chemical Information System'; Act No. 14532, 2018, article 48).

Considering the survey findings, apart from the notable difference in constraint recognition, problem and involvement recognition measures were considerably high for both groups. In this respect, there seems to be community 'appetite' for Natech risk communication in Japan and S. Korea. This was supported by a relatively high motivation to communicate; both Japanese and Korean citizens seem to be interested in learning more about Natech risk, thus resolving the meta-problem of information deficiency. Remarkably, Korean respondents perceived themselves as significantly less constrained and having considerably more ideas for solution than Japanese in dealing with this issue. Also, even though the observed discrepancy was marginal, Koreans were statistically significantly more motivated to communicate and resolve the problem. We would argue that these findings once again suggest that Korean legislation has introduced a chemical risk communication framework that addresses—to a certain extent—the community's informational needs, provides a direction for solution and creates a milieu that encourages communication about the issue.

Regarding citizens communicative behaviour, the most active component for both groups was by far passive information acquisition (i.e., attending). All other aspects exhibited statistically significant differences between the Japanese and Korean samples, and—with the exception of information permitting—were more pronounced in the Korean group. Information permitting was actually higher for Japanese, albeit marginally. Taken together these findings mean that Korean residents search for, select and transmit information pertaining to Natech risk more actively than Japanese in their attempt to comprehend the involved chemical risk as well as how it is being handled by the authorities, and proceed accordingly (i.e., prepare against it or seek reassurance).

In fact, information forefending received the lowest score for the Japanese sample, thus indicating—along with the increased information permitting—an absence of strict information selection processes, according to STOPS (Kim & Grunig, 2011). This overall passive information selection behaviour observed from Japanese respondents likely suggests that individuals do not have already set opinions on how such risk information should circulate or even how chemical risks should be handled. They are still at an early stage of understanding the problem (Kim & Krishna, 2014), and thus look for any information available rather than 'filtering' their sources. In conjunction with high information acquisition behaviour patterns, Natech risk communication can be interpreted as a still complicated issue for citizens to comprehend and take a stance as they are still trying to gather information about it. This reasoning also aligns with the arguably passive role of communities in terms of chemical risk management in Japan (Shimizu, 2016; Mochizuki, 2014) on account of information deficiency.

Furthermore, organisation-public relations seem to play an important role in shaping citizens' situational perception for the issue of Natech risk information deficiency. Although, results were inconsistent across groups, this study found evidence suggesting that trust and shared decision-making power influence community perceptions about the meta-problem. First, the advocated relationship between trust and risk perception (Slovic, 1999) seems to play an important role in shaping the situational perception about the meta-problem of information deficiency problem, as well. More specifically, for the Japanese sample increased organisational trust correlated with a notable reduction in problem and involvement recognition.

Furthermore, a higher level of decision control-sharing appears to increase individuals' connection with the issue and further decrease perceived obstacles in taking action to resolve it. For the Korean sample, our findings only demonstrated a considerable reduction in perceived constraints from decision-making power-sharing, which was actually significantly stronger that the Japanese case. Therefore, we would argue that this power balance has a seeming alleviating effect on the citizens' situational perception about the Natech risk information deficiency. Again, this phenomenon is probably attributed to the underlying positive influence of transparency in policymaking on chemical risk perceptions (Renn & Kastenholz, 2000).

From the cross-national comparison, we observed that both organisational trust and control mutuality were substantially increased in S. Korea. Given the similarity between Japan and S. Korea in terms of power distance (Hofstede, Hofstede, & Minkov, 2010), we have little reason to base this discrepancy on different worldviews of hierarchical structures within their societies. From our point of view, this noteworthy difference is related to the chemical risk management framework introduced by the Korean government. The included chemical risk communication

provisions oblige companies to disclose information about the risk and the preparedness plans with local communities. It is probable that this enforced public discussion about risk cultivates relations among stakeholders and improves the cooperation climate overall (Chon, 2019; Ki & Hon, 2007; Bruning & Galloway, 2003). Supplementary, this reasoning is supported by our survey findings, where Koreans expressed significantly more trust towards government considering how access to Natech risk information is handled. Nonetheless, of course, we cannot exclude the existence of any underlying, hidden factors that were neglected from this study, such as the level of media attention the fatal chemical accident in Gumi received or the public outrage it may have caused (Park & Cruz, 2022; Jung & Park, 2016), which could have potentially influenced community awareness with respect to chemical accident risk. In this regard, further research is needed in this direction.

Finally, the questionnaire survey results demonstrated an interesting picture regarding the additional perceived sociocultural challenges for our issue. Rather unsurprisingly, the lack of chemical risk information was highlighted equally by Japanese and Korean citizens as an important obstacle that limits their understanding of the hazard. But beyond this direct association, citizens admitted their reservations that disclosing such information would negatively impact their regional economy, such as through property devaluation or decrease in trade and tourism. These discoveries are in line with past research studies about an inverse correlation between risk perception and land prices in general (McCluskey & Rausser, 2001) or specifically in the context of Japan (Naoi, Sumita, & Seko, 2010; Nakagawa, Saito, & Yamaga, 2009), while the advocated negative association with the local economy (Slovic et al., 1991) has been also confirmed. Interestingly, Koreans seemed to anticipate a more negative impact on the regional economy in general compared to property values. The inverse was true for the Japanese sample. Views were significantly different across the two groups—albeit marginally—which might be indicative of the different subjective value economic activities have for each society, or different reference criteria for evaluation. Additional research is invited to shed light on this aspect.

On the other hand, the anticipated effect of social desirability acting as a considerable barrier for community residents in asking for chemical risk information was rather discredited for the Japanese and Koreans, in spite of their collectivistic social structure (Kim & Kim, 2016; Hofstede, 2011). Japanese citizens do not seem to perceive their tendency to socially conform (Lalwani, Shrum, & Chiu, 2009; Bernardi, 2006) as an inhibiting factor in actively challenging the *status quo* concerning the issue of Natech risk information deficiency within the local community—or at least explicitly. Koreans, however, were slightly more inclined to believe that asking about the Natech risk would cause social discomfort. Perhaps this view is related to the social value of 'femininity'

once again (Hofstede, Hofstede, & Minkov, 2010); in this regard Koreans have a higher level of social empathy than Japanese do and may be even less inclined to discomfort others. Future researchers may consider examining in more depth the impact of social desirability as an obstacle to chemical and Natech risk communication.

Secrecy in chemical risk management is probably the cause of another noteworthy obstacle: distrust in risk communication. Japanese and Korean residents seem equally mindful of the fact that they are not expected to be actively engaged in decision-making pertaining to chemical risk. However, Japanese citizens expressed their distrust in how the government currently handles the issue of chemical risk information disclosure, but more alarmingly said they would find probable a scenario in which local authorities conspire with industries in withholding the real consequences from a chemical accident. Such reputational cascades tend to justify and enhance public concern—warranted or not—pertaining to hazards (Sunstein & Vermeule, 2009; Kuran & Sunstein, 1999), especially after a prominent triggering event that invoked analogous conspiracies in the past, in this case the Fukushima nuclear accident. Koreans in comparison have a positive example of institutional action, since their national government enacted the Chemical Substances Control Act in response to the Gumi chemical accident (Park & Cruz, 2022; Jung & Park, 2016). This is probably reflected through their significantly elevated trust in how access to chemical risk information is managed.

Lastly, the public segmentation revealed that more than 80% of the respondents in both samples were categorised as an aware and active/activist public. This essentially means that four out of five individuals acknowledge the issue of Natech risk information deficiency as a severe problem that personally affects their lives, thus indicating a propensity to communicate in order to resolve it (Kim & Ni, 2013; Kim, 2011). Comparing the two samples, we observe that the percentage of the active/activist public in the Korean group is more than double of the Japanese case. This suggests that Koreans are at more 'mature' communicative stage and have either started to or are about to begin communicating actively to address it (Kim & Krishna, 2014). This finding again is in line with our argument that the introduced chemical risk communication framework in S. Korea has contributed to activating their public in terms of searching, selecting and transmitting Natech risk information.

3.7.4 Policy Implications

Aside from the academic interest of this research in applying and evaluating STOPS in the discipline of Natech risk communication and in the sociocultural context of Japan, appreciating the citizens' perspective on chemical risk communication and management bears several concrete policy implications. On the one hand, this study brings to the fore opinions of common citizens,

individuals, who are usually—but not ideally—at the receiving end of chemical risk communication practices within the Japanese reality (Shimizu, 2016; Mochizuki, 2014). In doing so, this study advocates for meaningful and constructive dialogue among all involved stakeholders and stake-seekers, placing due emphasis in actively engaging local communities in participatory risk management methods. Risk communication is understood as the foundation of participatory risk management, and a community's right-to-know as the cornerstone of risk communication (Palenchar, 2008; Hadden, 1989; Baram, 1984).

Following this principle and acknowledging that any sort of cooperative scheme for risk-related decision-making among governments, businesses and societies should be based on mutual respect, this study set out to examine potential differences in communicative behaviour of citizens in Japan and S. Korea concerning the issue of Natech risk information disclosure. Considering the relative cultural similarity of the two societies, the cross-national comparison aimed at highlighting dissimilarities facilitated by the different institutional environments. Supporting our initial argument that risk communication cultivates a cooperation climate and encourages further stakeholder discussion, the findings of this research endeavour showed emphatically that Koreans were considerably more communicatively active overall than Japanese.

First and foremost, both Japanese and Korean citizens indeed have an 'appetite' for risk communication and information disclosure concerning chemical and Natech accidents. Considering the Japanese reality from a chemical risk management standpoint, regulatory reforms aimed at introducing and fostering community right-to-know initiatives are certainly warranted based on the residents' eagerness. Not only they recognised the problem of information deficiency as significant and in direct connection with their lives, but also explicitly characterised this lack of publicly available chemical risk information as an obstacle that prohibits them from appreciating the real situation. Furthermore, the vast majority of the participants seem to fall under the categories of aware and active/activist publics, indicating that a large part of the community is increasingly acknowledging this issue of risk information deficiency, whilst risk perceptions about chemical and Natech accidents were also elevated. Substantial evidence indicated that this increased situational motivation of citizens to do something about this presented discrepancy is being channelled into communicative action, while their efforts intensify in seeking and acquiring information about the problem.

In comparison, although perceived severity and personal involvement with the meta-problem was equally high, Koreans recognised obstacles to be significantly lower when considering how to resolve the issue. Likewise, Koreans had considerably more ideas for solution and showed an elevated motivation to communicate. This in turn translated into a more active

communicative attitude as reflected by their actions. Considering the larger portion of communicatively 'mature' publics within the Korean sample along with their expressed trust in how access to information is handled, we would argue that the recently introduced chemical risk information disclosure has facilitated a positive stakeholder cooperation climate and encouraged meaningful Natech risk communication with citizens.

All of the abovementioned arguments make for a strong case for risk managing authorities in Japan and elsewhere to adopt and promote policies targeted at openly sharing information about actual chemical and Natech hazards and associated risks. What is important to reiterate here is that the consequent benefits are mutual (see UNISDR, 2015; OECD, 2003). On the one hand, transparency encourages deliberation processes and consensus-building for appropriate mitigation measures and promotes understanding and acceptance of technological risks. Moreover, fostering institutional support is key in reducing social concerns for uncertain, complex and ambiguous risks (Aven & Renn, 2010). On the other hand, the community's capacity to cope effectively with a chemical or Natech accident scenario is enhanced via risk communication. Households become adequately informed of the potential hazardous scenarios they might face, as well as the warning systems and contingency plans in place and therefore can prepare their response actions accordingly (Palenchar, 2008).

Heeding to international calls for the promotion of inclusive and transparent risk communication strategies (e.g., *SDGs*, *SFDRR 2015–2030*, *OECD's Guiding Principles for Chemical Accident Prevention, Preparedness and Response*), policymakers are recommended to pursue, foster and institutionalise community participation in risk-related decision-making for chemical and Natech risks (see UN, 2015; OECD, 2003, 2015; UNISDR, 2015), starting from designing the regulatory tools for citizens to access such information. Regulatory frameworks, such as *EPCRA* and the *Seveso Directives*, can serve as inspirational examples on how to initially address the subject. Of course, adjustments that take into account the Japanese *modus operandi* pertaining to technological risk management are in order, if there is going to be a serious effort in introducing effective changes in regulation; simply copying best practices from various settings rarely produces desired results. In this regard, perhaps drawing inspiration from the Korean '*Chemical Substances Control Act*' (see Act No. 14532, 2018) can be a particularly helpful reference point. Given the similar sociocultural context of the two countries, there may also be shared challenges pertaining to Natech risk perception. The implementation of the Korean regulation can provide constructive guidance for the Japanese chemical and Natech risk management system in terms of risk communication, to identify persistent challenges and easily-transferable good practices. From a disaster risk management perspective, the benefits of pursuing international cooperation—

even—to further propose and develop chemical and Natech risk communication guidelines are great.

For the next steps, risk management authorities should orient towards supporting continuous and constructive civic discourse throughout risk management processes, as well as invest in trust-building and sharing decision-making power equally among all involved stakeholders and stake-seekers. Agreeing with previous research on public relations (Chon, 2019; Ki & Hon, 2007; Bruning & Galloway, 2003), this study provided evidence suggesting that establishing and maintaining favourable organisational-public interactions based on communication improves community perceptions about the Natech risk information deficiency meta-problem. Considering the citizens' perceived problem, involvement and constraint recognition pertaining to the lack of risk information, the challenges arise from the exclusion of communities from the chemical risk management processes in the first place. Risk managers should aim at actively engaging citizens in order to address the associated concerns about the management of the chemical and Natech risk, thus reducing the perceived severity of risk information deficiency. Participatory approaches in risk management advocate for an inclusive multi-actor process that invites and involves representatives from the spheres of government, business and community (Solinska-Nowak et al., 2018; Mechler, 2016). Methods worth exploring in this direction entail, for example, citizen forums, negotiated rule-making exercises, mediation or advisory committees (Aven & Renn, 2010).

Another point to consider when drafting risk communication strategies is public segmentation based on the aforementioned perceptual variables. This conceptual approach can be a valuable aid for effective strategic risk communication, as it allows practitioners to break down the organisational environment into finer and more manageable elements in terms of power, resources or action potential. They can then develop tailored risk communication strategies and efficiently allocate resources to accommodate various priorities (Kim & Ni, 2013). By discerning the profile of citizens who comprise non-public, latent, aware and active/activist groups, risk managers can draft communication strategies to effectively target, approach and engage such publics in the risk management processes and address their (mis-)perceptions and concerns about the risk.

Furthermore, situational theory elements along with organisation-public relation assessment measures could serve as evaluation criteria for government institutions and industrial businesses for benchmarking and guidance for ethical business practices that take into account risk communication. Aligning with recent trends in corporate social responsibility (CSR)[12] studies,

[12] According to the United Nations Industrial Development Organization (UNIDO, 2022): 'Corporate Social Responsibility is a management concept whereby companies integrate social and environmental concerns in their business operations and interactions with their stakeholders'.

such measures can provide a framework for assessment of ethical/symmetrical communication practices (Grunig, 2018; Ni et al., 2015). Perhaps in consideration of industrial facilities handling potentially hazardous materials, ethical risk communication could also be incorporated as a CSR aspect to address public concerns and meet the expectations shareholders and stakeholders.

Finally, a cautionary note on organisational distrust. Potential conspiracy theories may not only damage the reputation of the involved government institutions and private stakeholders, but furthermore they may cultivate the belief that any hazard and risk information provided by an official source is deliberately misleading (Kinchy & Schaffer, 2018). Not addressing such an issue would be indeed worrying for the drafting and implementation of risk communication strategies, as they would be highly unlikely to yield any desirable results in the direction of community engagement in risk management. At worst case scenario, households might reach such a level of distrust towards risk messages from the government and/or industries, where they would grossly underestimate the accident risk, disregarding preparedness instructions and even emergency risk warnings.

3.8 Conclusions

This study contributed to the advancement of Natech risk communication by expanding the current understanding regarding how citizens communicate about Natech risk information disclosure through a cross-national comparison. Our approach framed the issue of Natech risk information deficiency as a cognitive *meta-problem* that stems from the underlying Natech accident risk. Following the narrative of the Situational Theory of Problem Solving, individuals perceive this *meta-problem*, and become motivated to communicate in order to solve it. In this context, this research ventured to investigate specifically the situational perceptions and communicative behaviour of citizens concerning the issue of Natech risk information deficiency. In an attempt to delineate and analyse any potential discrepancies in how individuals from similar sociocultural backgrounds, but embedded in dissimilar chemical risk governance systems, communicate about Natech risk information disclosure, we conducted a cross-national, comparative study between Japan and S. Korea. Moreover, we introduced two key Organisation-Public Relations assessment measures, so as to evaluate the impact of trust and perceived decision-making power-sharing on citizens' perceptions and motivation to communicate. Finally, we examined additional, potentially influencing factors such as Natech accident risk perception, certain social norms and perceived downsides to disclosing chemical risk information.

We collected survey data from households near prominent industrial parks in Osaka and Kobe in Japan, and Yeosu, Suncheon, Gwangyang and Ulsan in S. Korea. Our research findings demonstrated an increased community 'appetite' for Natech risk communication in Japan and S.

Korea, as both groups appeared to be interested in learning more about Natech accidents in order to resolve the *meta-problem* of risk information deficiency. Nonetheless, Korean respondents seemed considerably less constrained and having more ideas for solution than Japanese in dealing with this issue. Additionally, Koreans exhibited higher communicative activeness in general indicating that they intend to search for, select and transmit information pertaining to Natech risk more actively than Japanese. Along with the elevated levels of institutional trust and perceived mutuality in decision-making power in S. Korea, and the overall confidence in responding to Natech scenarios, our findings suggested that the Korean chemical risk information disclosure approach has probably contributed positively in alleviating the *meta-problem* of Natech risk information deficiency. Such results provide important evidence for risk managers and policymakers, providing a basis for regulatory reforms that promote chemical risk information transparency and encourage citizen participation via risk communication strategies.

Certain methodological issues emerged during our analysis. First, despite the model's apparent statistical robustness in explaining the variance observed in our dataset, this study acknowledges there may be additional influencing factors that might have been omitted from our analysis. Therefore, further research is required to delineate a more comprehensive picture of the potential influencing factors for Natech risk communication. Perhaps future works may consider expanding on the presented STOPS and OPR models used in this study by borrowing conceptual constructs from other approaches or proposing new ones. Moreover, there were certain issues with the observed variables. For example, the latent variable of Constraint Recognition fell just short of the strict construct reliability threshold, even after deleting the most troublesome item. Nonetheless, it was retained in our model in order to better understand and compare Natech risk communication challenges between Japan and S. Korea. This limitation may stem from the measurement tool, and more precisely the item phrasing, rather the conceptual framework itself. Future research is advised to pay attention on how perceived obstacles about Natech risk communication are carefully measured to overcome such drawbacks.

Moreover, as far as the cross-national comparison is concerned, an in-depth cross-cultural study that would involve sociocultural constructs, comparing the two samples at a national level was beyond the scope of this research. It may be argued that our approach combined responses from individuals of different sociocultural backgrounds, and so may have introduced—inevitably—some culture-specific biases. Even though we tried to control for this aspect in our analysis, this research topic would greatly benefit from a full-fledged cross-cultural study which would incorporate sociocultural dimensions to effectively identify and disambiguate their effects on situational variables. Future research may also consider exploring the influence of sociocultural

factors on individuals' situational variables and motivation to communicate about the issue of Natech risk information disclosure. Finally, our data collection strategy did not prioritise obtaining more representative population samples that would permit generalisations and a comparison at the national level between Japan and S. Korea. Instead, we followed more technical criteria, targeting households under immediate risk from a potential Natech accident at the neighbouring industrial facilities. Resource limitations did not allow for a sampling strategy that would control for the location and the demographic profile of respondents at the same time, thus resulting in noteworthy demographic discrepancies between the two samples. In this vein, future researchers are invited to examine the topic using different sampling techniques (*e.g.*, stratified sampling) based on various demographic criteria (*e.g.*, gender, age, education, income, and so forth), especially if aiming for accurate inter-group comparisons across regions. Finally, our study did not explore the potential influence of survey participation incentives on the quality of responses in an opinion questionnaire about disaster risk communication and perception. Likewise, more studies are required to appreciate the effects of such aspects.

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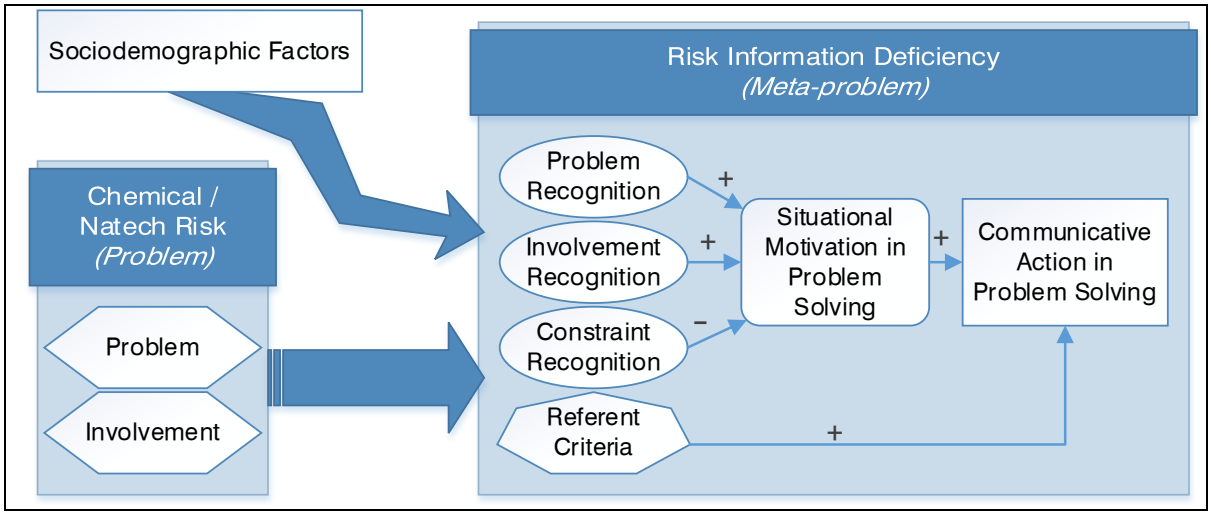
Chapter 4 Sociodemographic Influences on Public Interest in Natech Risk Information: Insights from Japan and S. Korea

4.1 Introduction

Over the years, research scholars have highlighted the exchange of information between experts and communities as the *sine qua non* for stakeholder involvement and risk governance (Renn & Klinke, 2013; Aven & Renn, 2010; Renn & Walker, 2008), and particularly so in the context of industrial, nuclear and environmental accidents (Palenchar, 2008; Shapiro, 2005). Risk communication and information disclosure have recently started to attract more academic attention in the Natech accident risk discourse (Suarez-Paba et al., 2020; Figueroa, 2013). Natech constitutes a special type of event that entails technological accidents triggered by a natural hazard and involves the release of hazardous materials (UNDRR-APSTAAG, 2020; Suarez-Paba et al., 2019; Cruz & Suarez-Paba, 2019). They are considered low-probability but high-consequence events with severe impacts on the regional population, environment and economy. Typical examples of Natech include the Fukushima nuclear accident following the Great East Japan Earthquake and Tsunami (GEJET) in 2011 (Cruz & Krausmann, 2013) and the oil spills that occurred during Hurricanes Katrina and Rita (Cruz & Krausmann, 2009).

Figure 4.1-1 Conceptualisation of sociodemographic determinants and risk information deficiency



Source: Original work

Disclosure of hazard and risk information allows communities to enhance their preparedness against potential disasters through sharing crucial information with the public. Also, disclosure paves the way for the civic discourse about the decision-making processes involved in risk management (Aven & Renn, 2010; Gutteling & Wiegman, 1996). Analysing this idea within the specific context of chemical and Natech accidents, Figure 4.1-1 describes two kinds of 'problems' from the perspective of risk communication. On the one hand, individuals perceive the underlying

Natech accident risk itself as the initial problem that directly or indirectly affects their lives to various perceived degrees. This issue is typically the subject of risk perception studies that explore how risk is socially understood and experienced (Wachinger & Renn, 2010). On the other hand, if chemical and Natech risk communication is limited—or even non-existent—individuals may find themselves lacking necessary hazard or risk information about the potential accidents, which is otherwise crucial for their effective preparedness and response to a potential event. In this regard, information deficiency presents a secondary problem that directly stems from the initial accident risk. Individuals then form their own perceptions about this issue in terms of its acknowledged severity, personal views, associated challenges and so forth.

Kim and Grunig (2011) approached this problematic situation from a public relations and mass communications standpoint, defining this discrepancy as a *cognitive meta-problem* that follows the initial perceptual problem: '*one's perception that something is missing and that there is no immediately applicable solution to it*' (p. 128). This conceptualisation presents a unique opportunity to study the issue of Natech risk information deficiency through the lens of Situational Theory[13]. Even though perception about this meta-problem is not the same as the Natech risk perception *per se*, it can be argued that they are related: the higher the concern about a potential Natech accident, the more salient the issue of information deficiency becomes to the individual. The argument is that by utilising the interpretative framework provided by the Situational Theory of Problem Solving (STOPS) (Kim & Grunig, 2011), risk communicators can identify and understand the behaviour of publics with increased communicative activeness. These types of publics are more likely to diligently search for, review and synthesise available information and, furthermore, reciprocate the efforts and engage in two-way communication (Grunig & Kim, 2017). Therefore, focusing on communicative actors allows risk managers to learn more about the community's demands, fears and (mis-)perceptions concerning both the risk information deficiency and the underlying risk in order to effectively address them and take their interests into consideration in the decision-making process (Grunig, 2018).

Furthermore, developing an effective methodology to identify and categorise stakeholder groups has been the Holy Grail and a recurring topic of debate among risk communication and

[13] The Situational Theory posits that publics can be identified and segmented from a larger population according to the level of activeness or passiveness of their communication behaviour. Grunig conceptualised the original Situational Theory of Publics (STP) in the '60s as a framework to understand when people communicate and what is the role of information in their decisions. Kim and Grunig (2011) then introduced the Situational Theory of Problem Solving (STOPS) as an extension and generalisation of STP that explains why and how individuals communicates during a problematic situation. For a detailed review of the historical development of the situational theory, interested readers are referred to Kim and Grunig (2011) and Kim and Krishna (2014).

perception researchers for several decades. Creating a reliable segmentation method aims to tailor risk communication strategies to targeted audiences for the purposes of increasing a communication plan's efficacy and maximising the yield of invested resources. In this context, sociocultural and demographic factors have frequently come under scrutiny as potentially potent and robust predictors of individuals' risk attitudes, perceptions and behaviours for an array of natural and technological hazard types (e.g., Sund, Svensson, & Andersson, 2017; Savage, 1993; for a review see Wachinger & Renn, 2010). Hence, sociodemographic influences have been widely regarded as valuable inputs for disaster risk managers and policy-makers in their quest to understand and predict disaster risk perception.

Nonetheless, this risk perception research is still in its infancy with very limited studies so far within the emerging field of Natech risk communication (Cruz & Suarez-Paba, 2019). Yu et al. (2017) was one of the first studies to focus on households' Natech risk perception and evacuation behaviour during the GEJET 2011 around an oil refinery complex in Sendai, Japan. Demographic characteristics did not prove to be strong predictors of Natech risk perception based on their findings, but the authors proposed that further investigation is required. Quite recently, Slack et al. (2020) investigated hazard perceptions in conjunction with institutional trust vis-à-vis Hurricane Harvey in 2017 by surveying households along the Texas Gulf Coast, of the United States. They utilised demographic attributes rather as supplementary controls for their primary research focusing on institutional distrust, but—as with the aforementioned study—their model coefficients did not suggest strong effects.

Given the little research available and considering the inconclusive results of previous studies on the subject of sociodemographic determinants of Natech risk perception, we follow a novel approach that is based on a communicative framework (for reasons explained above), rather than on the Psychometric Paradigm (see e.g., Slovic, 2000; Slovic et al., 1981) or the Cultural Theory of Risk (see e.g., Breakwell, 2007; Douglas & Wildavsky, 1982) that have been used so far. Our main research question is: *Do sociodemographic factors influence citizens' situational perception and motivation to communicate with each other about the issue of Natech risk information deficiency?* More specifically, we venture to explore whether and how households' sociodemographic characteristics affect their perceptions of the meta-problem of chemical and Natech risk information deficiency. By doing so, we intend to shed some light on the influence of sociodemographic variables on situational perception elements about this issue.

In a basic attempt to reveal any underlying institutional parameters, we looked at households near industrial complexes in two countries that share a relatively similar sociocultural background: Japan and South Korea. The cultural dimensions of Hofstede (2001) (*i.e.*,

collectivism/individualism and masculinity/femininity) are used to support our argument about the similarities of the two societal structures in terms of their organisational cultures (see e.g., Hofstede, Hofstede, & Minkov, 2010; House et al., 2004; Hofstede, 2001). Without disregarding, of course, the discrepancies when comparing the superordinate cultural groups (Park, Kim, & Zhang, 2016), the predominant characteristic of Japan and S. Korea generally appears to be collectivism. However, Japan seems to score higher on masculinity in contrast to the rather feminist organisational culture of S. Korea (Kim & Kim, 2016). Perhaps more important for our purposes though is the fact that Japan and S. Korea bear a stark difference in terms of chemical and Natech risk communication. S. Korea consolidated and updated its risk management and communication regulations with respect to technological accidents under a comprehensive law titled Chemical Controls Act. A recent amendment refined existing fragmented and outdated articles as well as introduced more detailed provisions regarding public disclosure of chemical information (Ministry of Environment, Republic of Korea, 2018). In contrast, despite its deep and advanced disaster education culture regarding natural hazards and regardless of international trends (e.g., Sendai Framework for DRR - UNISDR, 2015), Japan has yet to introduce any specific regulatory framework that includes standards for public disclosure of information related to chemical risks. Based on this situation, we selected the two countries for our study to explore any effects of the differences in the regulatory frameworks that govern chemical and Natech risk communication on the situational variables under study.

The rest of this chapter is organised as follows. Section 2 offers a brief overview of the perceptual and cognitive elements of STOPS used in our approach, and then summarises the findings of previous research on the influence of sociodemographic determinants on risk perception. Section 3 presents the research hypotheses and data collection methods. Section 4 describes the multivariate analysis methods employed. Section 5 includes the analysis results, while Section 6 synthesises and discusses the key research findings and considers policy implications. The final section offers a summary, and considers the study's limitations and future research prospects.

4.2 Literature review

4.2.1 Perceptual and Cognitive Variables of Situational Motivation

Situational approaches that use latent constructs (*e.g.*, individual behaviour, cognition) have proven advantageous in analysing the dynamic nature of publics (Chon, 2019; Kim, Ni, & Sha, 2008). This research endeavour employs the four perceptual and cognitive variables of the Situational Theory of Problem Solving (STOPS), namely Problem Recognition (PR), Constraint Recognition (CR), Involvement Recognition (IR) and Referent Criterion (RC), along with Situational

Motivation in Problem Solving (SM) (Kim & Grunig, 2011), to address the issue of Natech risk information deficiency. Researchers have used the situational variables in the past to effectively identify communicatively active public segments (Kim, Miller, & Chon, 2016; Ni & Kim, 2009), as well as to plan communication strategies and predict individuals' communicative behaviours (Chon, 2019).

STOPS posits that individuals assume a communicatively active behaviour in terms of acquiring, selecting and transmitting information when they become committed to problem solving (Kim & Grunig, 2011). This Communicative Action in Problem Solving (CAPS) is dictated by the individual's situational motivation along with any available referent criteria, that is, past experiences, subjective knowledge or expectations applicable to the issue (see Figure 4.1-1 for a visual representation). Situational motivation is conceptualised in turn as the product of the three antecedents; problem, involvement and constraint recognition. The first element refers to the perceived severity of the situation, the second to the perceived personal relationship with the problematic situation, and the last to the perceived barriers that limit one's ability to communicate about the problem (Kim & Krishna, 2014; Kim & Grunig, 2011). Translating STOPS into the context of Natech risk communication, individuals perceive the meta-problem stemming from the risk information deficiency, their personal connection with it and the challenges that limit their ability to take action to resolve it. Based on their knowledge, subjective judgmental rules (e.g., moral or cultural issues) and expectations about how Natech risk information should be handled, their situational motivation drives them to engage in communicative action.

Finally, STOPS has been successfully applied in multiple fields, including health communication and post-incident public relation crisis communication among others (Kim & Krishna, 2014). Its potential only begun to be explored in the field of chemical risk communication. Furthermore, it has been used in various sociocultural settings, including Asian countries and particularly S. Korea (Chon, 2019; Kim et al., 2012).

4.2.2 Sociodemographic Factors and Risk Perception

Our attention focuses on cross-situational elements, namely sociodemographic features of involved citizens, as external influential factors that may—or may not—shape the individual's situational perception and problem-solving motivation. Since studying the individuals' opinions concerning the issue of risk information disclosure so systematically is a relatively novel endeavour, the demographic determinants of situational perception have not been thoroughly documented and understood yet. At first glance, the topic may be examined from a public relations perspective focusing on the motivation to communicate and its situational antecedents, while an approach based on risk perception is also warranted due to the specific nature of the issue.

In the former case, researchers working with Situational Theory examined sociodemographic factors that were hypothesised to define individuals' situational perception towards a given problem, with rather modest results. Kim et al. (2012), for example, tested the effects of gender, age, education level and income on individuals' situational perception for topics that receive mass media coverage only to find a significant, moderate influence of age on reducing problem and involvement recognition. Correspondingly, Lovari et al. (2012) studied the influence of similar demographics on situational perception for civic issues (i.e., unemployment, safety, transportation), finding a statistically significant association and small effect between age and problem recognition. This time, a positive direction was found, meaning that age slightly increased problem recognition. As a general rule, Situational Theory academics have argued that cross-situational variables, such as demographic characteristics of individuals, do not exert any substantial effects in comparison to the situational factors (Kim et al., 2009, 2012; Grunig, 1997), which has also been confirmed in the aforementioned studies.

Perhaps more interesting, however, is the fact that the specific origin of the problem under question is intrinsically tied to risk perception about the underlying chemical and Natech accident risk. This rationale explains why it is important to reconsider the effects of sociodemographic factors on situational perception in the context of risk. Actually, the literature about the influence of key demographic characteristics on risk perception is plentiful. Researchers introduced a wide range of contributing factors from physical attributes (*e.g.*, gender and age) to socioeconomic aspects (*e.g.*, education, marital status and income level). Nonetheless, the results were not always definitive, while even the direction of some relationships depended on the particular case study.
Possibly the most studied demographic determinant is gender, as Rowe and Wright (2001, p. 384) remark. A consistent motif in the risk perception studies is that males typically tend to regard risks as smaller and less problematic compared to females (Slovic, 1999; Savage, 1993). This finding was confirmed in the case of man-made hazards, namely radioactive waste disposal and global warming (Davidson & Freudenburg, 1996). Later research also supported this finding across various types of risk, including natural hazards among others (Sund, Svensson, & Andersson, 2017), or with reference to disaster preparedness measures for floods (Cvetković et al., 2018). Nonetheless, findings have not always revealed an increased risk perception by women. For example, Slack et al. (2020) observed that gender had no statistically significant influence on an individual's level of worry about future impacts of tropical storms. Several researchers noted the ambiguity of this factor's effect on risk perception for a variety of natural hazards, ranging from volcanic and seismic to hydro-meteorological. Their respective analyses revealed that previous

exposure to such hazards was actually the underlying cause of fluctuation in risk perception levels (Wachinger & Renn, 2010; Barberi et al., 2008; Kunz-Plapp & Werner, 2006).

Another demographic characteristic commonly included in risk perception studies is age. Despite the number of studies looking at the relationship between these two aspects, major inconsistencies seem to emerge from the findings (Kim & Madison, 2020; Slack et al., 2020; Cvetković et al., 2018; Wachinger & Renn, 2010). For instance, one study on single-family homeowners residing in Florida found that age was actually correlated with reduced hurricane risk perceptions (Peacock, Brody, & Highfield, 2005). Furthermore, Huang et al. (2012), reported an association between older individuals and lower risk perception in the case of Hurricane Ike, and reasoned that perhaps older people anticipated smaller personal impact from that particular hazard. On the other hand, other researchers, such as Sjöberg (2004), demonstrated a positive correlation between older individuals and risk associated with nuclear waste. It is clear that consensus has not yet been reached on this matter. As far as Natech risk is concerned, researchers pointed out that older persons residing near an industrial area in Sendai reported higher degrees of concern about their lives and properties being affected by an accident following the Great East Japan Earthquake, even though age—the study noted—did not appear to be a persistent and strong determinant (Yu, Cruz, & Hokugo, 2017).

Concerning the effects of individuals' educational attainment on risk perception, Wachinger et al. (2013) concluded that people with different educational levels show differences in risk perception regarding natural hazards. Other studies suggest an inverse correlation between the two: highly educated people demonstrated decreased perceived risk (Kim & Madison, 2020; Cvetković et al., 2018; Sund, Svensson, & Andersson, 2017; Rowe & Wright, 2001; Savage, 1993) for various risk domains, including natural hazards. Nonetheless, there have been instances where research efforts failed to discover any significant correlations between risk perception and level of education (Sjöberg, 2004). Sundblad et al. (2007) also considered the potential effects of education attainment on risk perception about climate change, arguing that a higher educational level may increase a person's sense of control and therefore reduce perceived risk. This seems to be the case in terms of chemical hazards, as well. One study found evidence to associate higher education with less concern about chemical risk and more favourable attitudes towards related technologies (Kraus, 1992 cited in Rowe & Wright, 2001), while another study revealed that higher educational level reduced the perceived risk associated with radioactive waste disposal (Flynn et al. 1993 cited in Rowe & Wright, 2001). Lastly, Sund et al. (2017) noted that education could also be connected to individuals placing excessive value on the 'correctness' of probabilities and consequences of potential accidents, which in turn may increase or decrease the associated

perceived risks based on the level of risk misperception within the general population. Considering the particular topic of this research, however, it is noteworthy that Kim and Madison (2020) identified a positive correlation between educational level and information-seeking efficacy in terms of flood risk.

Furthermore, income has been proposed as an additional influential sociodemographic factor, but once again the findings have been mixed. Lower income levels have been linked to an increase in risk perception for technological and natural hazards in the past (Savage, 1993). Fothergill and Peek (2004) suggested that individuals with lower income have elevated risk perceptions because of restricted control, potential technological ignorance, lack of social integration that provides them access to risk communication mechanisms, and amplified fear of losing their houses and livelihoods. More recent studies also support this inverse correlation between risk perception and income level in the context of natural hazards (Kim & Madison, 2020; Sund, Svensson, & Andersson, 2017). Nonetheless, there have been cases where a significant association between these factors could not be supported by the results (Cvetković et al., 2018; Sjöberg, 2004). While a few studies have pointed to a significant relationship between income and risk perception (Donner & Rodríguez, 2008; Lindell & Hwang, 2008), the literature review conducted by Wachinger and Renn (2010) led them to conclude that economic factors generally (with the exception of homeownership) do not seem to have a significant influence either on risk perception or willingness to adopt preparedness measures.

Household size was also tested as a determining factor of risk perception and protective action. In the context of tropical storms, larger families showed decreased likelihood of evacuating their houses (Dash, 2002). Later research also confirmed this inverse relationship between household size and evacuation likelihood with statistically significant, strong predictors, but revealed that household composition might play an important role as well (Dash & Gladwin, 2007). In detail, larger households with children showed a higher propensity to evacuate during a hurricane, while larger households with elderly members were less likely to do so (Solis, Thomas, & Letson, 2009; Dash & Gladwin, 2007). Such a negative relationship between family size and hurricane evacuations in Florida was demonstrated by Solis et al. (2009), although results were statistically insignificant. In the context of Natech risk, however, Yu et al. (2017), in their study on the evacuation behaviour following the oil refinery explosion, could not find any significant evidence to either support or reject this correlation.

One of the—admittedly—less-investigated factors in risk perception research is having dependents in the household. Kim and Madison (2020) expected a positive relationship between risk perception and families with dependents, based on the premise that it is within human nature

for care-givers to feel a greater responsibility to protect those they take care of (be it children or elderly). Nonetheless, they could not find any statistically significant results to support this hypothesis when investigating the 2016 Louisiana floods in the United States. Moreover, Solis et al. (2009) examined the influence of the number of children and the existence of pets on household evacuation behaviour. Their statistically significant results suggested that households with more children were more likely to evacuate during major hurricanes in 2005 in Florida, but the opposite was true for households with pets. As far as marital status is concerned, studies have failed to find any conclusive and statistically significant results to support either a positive or negative correlation (Xu et al., 2018; Basolo et al., 2009). However, there has been evidence suggesting that single individuals are more likely to prepare emergency supplies in case of flood (Cvetković et al., 2018).

As explained above, social and individual factors—aside from gender—do not seem to play a significant role but may act as mediators or amplifiers between the connections of risk perception, public trust and disaster preparedness (Wachinger et al., 2013). Yet, the interest in the correlation between sociodemographic variables and risk perception still grows, despite the unfruitful research efforts so far. Lindell (2013) acknowledges that, although these variables continue to be unreliable predictors, their potential in helping experts better understand stakeholders' risk perception is great. If nothing else, it is exactly these inconclusive research findings that fuel interest in discovering any underlying linkages between individual sociodemographic aspects and risk perception. This interest is particularly strong in the emerging field of Natech risk, where the influence social and individual factors exert on people's risk perception and protective actions has only recently started to be examined (e.g., Slack et al., 2020; Yu, Cruz, & Hokugo, 2017).

4.3 Methodology

4.3.1 Research Aim and Hypotheses

This study explores whether and how households' sociodemographic characteristics affect their perceptions about the meta-problem of Natech risk information deficiency. Japan and S. Korea are both highly industrialised countries, with a few of their largest industrial complexes being located along their eastern coastlines. S. Korea—unlike Japan—is not located in a seismically active region, and the geomorphology of the greater region may be protecting it from potential devastating tsunamis, yet both countries are subject to large tropical storms originating from the Pacific Ocean, heavy rainfalls and landslides almost at a yearly rate. Hence, it can be argued that both countries are at a relatively high risk of Natech accidents happening.

As explained earlier, the main research aim is as follows: *Do sociodemographic factors influence citizens' situational perception and motivation to communicate with each other about the issue of Natech risk information deficiency?* Considering the infancy of Natech risk communication and perception research and the novelty of the STOPS framework in the risk communication field, this study adopts an exploratory approach. Its modest aim is to investigate at an introductory level the sociodemographic influences on situational variables. Thus, the focus is primarily on developing hypotheses for future work. Specifically, this research investigates eight factors: gender, age, educational level, annual household income level, the existence of a spouse, of children and finally, and whether the respondent lived in Japan or S. Korea.

For the purposes of this study, a 'positive effect' on the situational variables is conceptualised as a contribution to the factors that in turn increase the individuals' communicative activeness concerning the meta-problem of Natech risk information deficiency. In detail, an increase in the variables of situational motivation (along with its respective antecedents) and referent criteria is considered as positive. It should be noted that, due to the intrinsic negative aspect of Constraint Recognition, such a 'positive influence' on Constraint Recognition from any sociodemographic factor is hypothesised as an inverse relationship between the two variables and *vice versa*.

The following assumptions are formed based on the literature review from the standpoint of risk perception. Males are likely to underestimate risks; therefore, the subsequent information deficiency problem is not regarded as prevalent, which is hypothesised to reduce the individual's communicative activeness about it. Moreover, older citizens have been facing the risk and the associated information deficiency problem for longer, and thus, they are expected to perceive it as more severe, but find it more difficult to resolve it. Similarly, education is anticipated to increase individuals' awareness about the risk and subsequently about the lack of information. However, higher levels of education may also provide the means to do something about the problem. Additionally, the larger the household is, the more individuals are exposed to the risk; hence, the perceived situation is hypothesised to be exacerbated. Conversely, a higher income level means more resources are available to effectively cope with the situation, so the problem is not expected to be perceived as large. Hypotheses are similar in the case of the existence of a spouse and children. Having a (co-)dependent household member is anticipated to increase concerns about the meta-problem without delineating any immediately available solution to it, which in turn impels communicative action. Finally, Koreans are expected to be comparatively less concerned about the meta-problem because they have a regulatory framework about chemical risk information disclosure in effect. The chemical risk communication mechanisms in place are hypothesised to

provide some ideas about how this issue could be resolved, while reducing the perceived challenges and inviting communication.

Table 4.3-1 Research Hypotheses

Variable	Gender	Age	Education	Income	H. Size	Spouse	Children	Country
PR	$H1_a$: –	$H2_a$: +	$H3_a$: +	$H4_a$: –	$H5_a$: +	$H6_a$: +	$H7_a$: +	$H8_a$: –
IR	$H1_b$: –	$H2_b$: +	$H3_b$: +	$H4_b$: –	$H5_b$: +	$H6_b$: +	$H7_b$: +	$H8_b$: –
CR	$H1_c$: +	$H2_c$: +	$H3_c$: –	$H4_c$: –	$H5_c$: –	$H6_c$: –	$H7_c$: –	$H8_c$: –
RC	$H1_d$: –	$H2_d$: +	$H3_d$: +	$H4_d$: –	$H5_d$: +	$H6_d$: +	$H7_d$: +	$H8_d$: +
SM	$H1_e$: –	$H2_e$: +	$H3_e$: +	$H4_e$: –	$H5_e$: +	$H6_e$: +	$H7_e$: +	$H8_e$: +
Notes: Problem Recognition (PR), Involvement Recognition (IR), Constraint Recognition, Referent Criterion (RC) and Situational Motivation (SM).								

Source: Original work

The arguments above can be formulated in a more operationalised format (Table 4.3-1). Gender has a negative effect on Problem Recognition (***$H1_a$***), Involvement Recognition (***$H1_b$***), Referent Criteria (***$H1_d$***) and Situational Motivation (***$H1_e$***), and a positive effect on Constraint Recognition (***$H1_c$***). Age has a positive effect on all Problem Recognition (***$H2_a$***), Involvement Recognition (***$H2_b$***), Constraint Recognition (***$H2_c$***), Referent Criteria (***$H2_d$***) and Situational Motivation (***$H2_e$***). Education has a positive effect on Problem Recognition (***$H3_a$***), Involvement Recognition (***$H3_b$***), Referent Criteria (***$H3_d$***) and Situational Motivation (***$H3_e$***), and a negative effect on Constraint Recognition (***$H3_c$***). Income has a negative effect on all Problem Recognition (***$H4_a$***), Involvement Recognition (***$H4_b$***), Constraint Recognition (***$H4_c$***), Referent Criteria (***$H4_d$***) and Situational Motivation (***$H4_e$***). Household size has a positive effect on Problem Recognition (***$H5_a$***), Involvement Recognition (***$H5_b$***), Referent Criteria (***$H5_d$***) and Situational Motivation (***$H5_e$***), and a negative effect on Constraint Recognition (***$H5_c$***). Likewise, the existence of a spouse has a positive effect on Problem Recognition (**$H6_a$**), Involvement Recognition (***$H6_b$***), Referent Criteria (***$H6_d$***) and Situational Motivation (**$H6_e$**), and a negative effect on Constraint Recognition (***$H6_c$***), and children has a positive effect on Problem Recognition (***$H7_a$***), Involvement Recognition (***$H7_b$***), Referent Criteria (**$H7_d$**) and Situational Motivation (***$H7_e$***), and a negative effect on Constraint Recognition (**$H7_c$**). Finally, the country of residence has a negative effect on Problem Recognition (***$H8_a$***), Involvement Recognition (***$H8_b$***) and Constraint Recognition (***$H8_c$***), and a positive effect on Referent Criteria (***$H8_d$***) and Situational Motivation (***$H8_e$***).

4.3.2 Data Collection

Data were collected via self-administered, anonymous household questionnaire surveys. A seven-point Likert-type scale ranging from 1 = 'Strongly Disagree' to 7 = 'Strongly Agree' was used to code the responses for the situational variables. At least three items per latent construct were included as a rule. The wording of the questions was based on measurement items tested and

validated in previous applications of STOPS (Chen, Hung-Baesecke, & Kim, 2017; Kim et al., 2012) with small adjustments where needed (see Table 4.3-2 for the survey measurement items). The initial version of the questionnaire was reviewed by a panel of 30 experts. After minor modifications to the items other than the verified STOPS measures, the questionnaire was translated by bilingual experts from English into Japanese and Korean, while a back-translation verified its effectiveness.

Table 4.3-2 STOPS Measurement Items

Problem statement	***There is a lack of publicly available information about potential chemical accidents at the industrial park in the area.***	
Problem Recognition (PR)	PR1	*I think this is an important problem.*
	PR2	*Government institutions should take action to solve this problem.*
	PR3	*Concerning this problem, I think there is a large gap between the way things should be and the way they are now.*
Problem Recognition (IR)	IR1	*This problem could have serious consequences for me.*
	IR2	*This problem could make a difference in my daily life.*
	IR3	*There is a strong relationship between myself and this problem.*
Constraint Recognition (CR)	CR1	*I believe I can improve the situation regarding this problem.*
	CR2	*My opinions matter to those in the government, who are working on this problem.*
Referent Criterion (RC)	RC1	*I have a clear idea about how to deal with this problem.*
	RC2	*I have an idea about how the government should approach this problem.*
	RC3	*I believe there are examples from other regions in Japan on how to deal with this problem.*
Situational Motivation (SM)	SM1	*I am curious about this problem.*
	SM2	*I frequently think about this problem.*
	SM3	*I want to better understand this problem.*

Source: Original work based on Kim et al. (2012) *and Chen et al.* (2017)

With the intent of collecting data from individuals exposed to a potential Natech accident, households within 2km from industrial installations were selected for this study. Areas with prominent industrial parks, neighbouring residential districts were targeted in both countries, specifically districts in Higashinada (Kobe) and Sakai-Senboku (Osaka) in Japan, and Yeosu, Suncheon, Gwangyang and Ulsan in S. Korea. For the Japanese sample, 2,630 questionnaires were distributed using post mail services resulting in *N*=330 [14] responses (12.47% response rate). Participation was completely voluntary without any financial incentive. The Korean sample (*N*=300; 100% response rate) was collected via an online survey employing the Tillion panel, the largest survey panel in the country, using locational restrictions. Participation was again voluntary, but a small financial compensation in the form of promotional coupons was provided to participants.

[14] 327 valid replies after discarding 2 unanswered questionnaires and 1 unengaged respondent (i.e., answered '7' throughout the questionnaire).

Data collection periods were January 26-March 8 in 2018 for the Japanese sample and March 9-18, 2020 for the Korean.

4.4 Analysis

The Japanese dataset required treatment for the missing values. The 327 responses were reduced to 317, after passing the Little's MCAR test, by excluding respondents whose questionnaire fill-out rate did not reach 90%. The remaining dataset was tried again using Little's MCAR test, justifying data imputation for the observed variables of each latent construct with the respective variable median[15] (Hair et al., 2010). The resulting Japanese dataset was then joined with the Korean. Preliminary reliability analysis for the combined dataset (*N*=617) exhibited robust latent construct validity for the five situational variables, as demonstrated by the Cronbach's α values that were above the .60 threshold. In detail: PR, α= .839; IR, α= .857; CR, α= .601 after the exclusion of 1 problematic item; RC, α= .718; and SM, α= .812. Next, the values for each of the five situational variables were calculated as the mean of their respective constituent, observed variables. Finally, listwise deletion was employed once again, this time based on the responses to the demographic variables, in order to produce the final dataset for the regression analyses.

Prior to building the regression models, a check for any multicollinearity among the independent variables was performed. Variance inflation factors (VIFs) were smaller than 2.51 across all models, which is well under the threshold of 5 that would point to any serious problems of multicollinearity. Moderate, statistically significant correlations, nonetheless, were observed between country and age (- .507, p <0.01), education (- .381, p <0.01), household size (- .370, p <0.01), spouse (- .349, p <0.01) and children (- .462, p <0.01), when correlation analysis was performed on the sociodemographic determinants. According to Belsley et al. (1980), fairly high statistical correlations among predictors are not always problematic in regression analysis. In this vein, predictors were included despite their significant, moderate correlation in order to control for them in the respective models. Durbin-Watson tests indicated no signs of dependency between observations for any model. Preliminary tests displayed no issues of non-linearity or homoskedasticity for any of the five models, suggesting thus that model specification could progress.

A series of Multiple Linear Regression analyses was conducted in order to test the formulated hypotheses and assess the effects—or lack thereof—of the sociodemographic factors on each of the situational variables. One model for each of the five dependent, situational variables was specified. In each model, all factors were entered in order to account for their effects

[15] This technique is not expected to alter the variable mean (Hair et al., 2010), since the percentage of missing information per variable did not exceed 2.3% (suggested threshold 10%).

regardless of the statistical significance of their respective coefficients. The general model is given by the expression as follows:

$$Y_{SitVar} = f(Gender, Age, Education, Income, Household\ Size, Spouse, Children, Country)$$

4.5 Results

First, the demographic profile for the Japanese and Korean samples was delineated with respect to their gender, age, level of education, annual household income level, number of household members, whether they had a spouse and children (Table 4.5-1). Even though at first glance the ratio of the Japanese and Korean sub-categories of the dataset seems to be well-balanced (a decent 55/45), a more detailed examination of their compositions reveals that the Japanese and Korean sub-categories of the dataset are quite different. Indeed, while almost 3 in 5 Japanese respondents were male, females comprise the majority in the Korean sub-group. The discrepancy becomes more prevalent concerning age. Almost 60% of the respondents are above 60 years old among Japanese respondents, whereas Korean respondents are no older than 59. Similarly, all Korean respondents had at least graduated from a vocational/technical school in contrast to Japanese 40% of whom had finished only elementary and high school education. Considering the annual household income level, the groups appeared to be fairly similar, with only slightly more Koreans identifying themselves in the middle tier. The remaining three categories display significant divergencies. Households of Japanese respondents seem to be much smaller comparatively, with only 20% of them exceeding 3 members, while more than half of the Korean households have at least 4 members. Additionally, 70% of Japanese respondents had a spouse compared to 96.8% of Koreans. Finally, a similar situation was observed with respect to children living in the household; almost 9 out of 10 Korean households had children, compared to only 4 in 10 within the Japanese group.

Concerning the five situational variables under study, Table 4.5-2 offers a brief overview of the descriptive statistics for the combined dataset. Bearing in mind that the midpoint of the 7-point scale used in this study was 4, the following can be deduced. First, problem and involvement recognition both have rather elevated means (i.e., 5.8 and 5.3 respectively), while their values of Skewness and Kurtosis suggest peaks at higher values—particularly so for PR with a comparatively smaller σ, too. The values for the other three variables indicate more equally distributed responses. Two more points are worth noting here. Referent criteria was the only variable with positive skewness, while the only variable embedded with a negative meaning, constrained recognition, also received relatively high responses.

Table 4.5-1 Summary of Sample Characteristics

Category	Country		Total	
	Japan	S. Korea		
	54,85%	45,15%	485	100%
Gender				
Female (1)	41,35%	53,42%	227	46,80%
Male (2)	58,65%	46,58%	258	53,20%
Age				
19 or younger (1)	0,38%	0,00%	1	0,21%
20 – 29 (2)	1,88%	2,74%	11	2,27%
30 – 39 (3)	10,15%	26,48%	85	17,53%
40 – 49 (4)	11,28%	34,25%	105	21,65%
50 – 59 (5)	16,92%	36,53%	125	25,77%
60 – 74 (6)	42,11%	0,00%	112	23,09%
75 or older (7)	17,29%	0,00%	46	9,48%
Educational Level				
Elementary School (1)	2,63%	0,00%	7	1,44%
High School (2)	36,47%	0,00%	97	20,00%
Vocational / Technical School (3)	15,04%	21,00%	86	17,73%
Bachelor Degree (4)	37,22%	73,52%	260	53,61%
Master Degree / PhD (5)	8,65%	5,48%	35	7,22%
Annual Household Income Level				
Low (0)	38,35%	15,07%	135	27,84%
Middle (1)	34,96%	57,53%	219	45,15%
High (2)	26,69%	27,40%	131	27,01%
Household Size				
1 Member (1)	19,17%	1,83%	55	11,34%
2 Members (2)	38,35%	21,00%	148	30,52%
3 Members (3)	23,68%	26,48%	121	24,95%
4 Members (4)	13,16%	40,18%	123	25,36%
5 Members (5)	4,14%	10,05%	33	6,80%
6 Members (6)	1,13%	0,46%	4	0,82%
7 or more (7)	0,38%	0,00%	1	0,21%
Spouse				
No (0)	30,08%	3,20%	87	17,94%
Yes (1)	69,92%	96,80%	398	82,06%
Children				
No (0)	58,27%	13,24%	184	37,94%
Yes (1)	41,73%	86,76%	301	62,06%
N= 485				

Source: Original work

Table 4.5-2 Descriptive Statistics of the Situational Variables

Situational Variable	***Mean***	***Std. Deviation***	***Skewness[1]***	***Kurtosis[2]***
Problem Recognition (PR)	5.82	.97	-1.095	1.747
Involvement Recognition (IR)	5.29	1.16	- .761	.557
Constraint Recognition (CR)	4.36	1.30	- .250	- .454
Referent Criteria (RC)	3.77	1.20	.164	- .446
Situational Motivation (SM)	4.63	1.20	- .465	.162
[1] Std. Error= 0.111 and [2] Std. Error= 0.221. *N= 485*				

Source: Original work

The results from the regression analyses for the five models are summarised next. Looking at the last two columns of Table 4.5-3, it becomes apparent that models R_1 and R_2 for predicting problem and involvement recognition are not statistically significant at the 95% confidence interval. Hence, conclusions concerning the influence of any of the sociodemographic factors on these two situational variables (i.e., $\boldsymbol{H1_a}$ through $\boldsymbol{H2_e}$) cannot be confidently drawn. Furthermore, the interpretative power of all models is quite small, even considering relatively low explanatory power standards typically found in psychological research (see Cvetković et al., 2018). R^2 values range from .047 to .12, meaning that the best performing model R_4 accounts only for 12% of the total variance observed in the referent criteria.

Table 4.5-3 Regression Model Fit Results Summary

Model	***Situational Variable***	**R**	**R^2**	**R^2 adj.**	**F** (8, 476)	***p***
R_1	*Problem Recognition (PR)*	.176	.031	.015	1.899	.058
R_2	*Involvement Recognition (IR)*	.175	.031	.014	1.886	.060
R_3	*Constraint Recognition (CR)*	.303	.092	.077	6.034	.000
R_4	*Referent Criteria (RC)*	.346	.120	.105	8.081	.000
R_5	*Situational Motivation (SM)*	.218	.047	.031	2.964	.003
N= 485						

Source: Original work

Moving on to the regression coefficients (Table 4.5-4), we observed that none of the estimated coefficients for education, income, household size, having a spouse or having children is statistically significant in any model. Therefore, hypotheses $\boldsymbol{H3_c}$ through $\boldsymbol{H7_c}$, $\boldsymbol{H3_d}$ through $\boldsymbol{H7_d}$ and additionally $\boldsymbol{H3_e}$ through $\boldsymbol{H7_e}$ cannot be confidently confirmed or rejected on account of insignificant evidence. On the other hand, respondents' gender appears to slightly increase constrain recognition ($\boldsymbol{H1_c}$) (B=.34, p<.01) and reduce situational motivation ($\boldsymbol{H1_e}$) (B= - .32, p<.01), thus supporting the original hypotheses. In terms of age, the initial assumption that it increased constraint recognition ($\boldsymbol{H2_c}$) (B= - .15, p<.05) was actually rejected, whereas its increasing effect on referent criteria ($\boldsymbol{H2_d}$) (B=.12, p<.05) was confirmed. Surprisingly, the only statistically significant

and strong effects were observed from the variable of country on constraint recognition (***H8$_c$***) and referent criteria (***H8$_d$***), confirming the expected relationships. Both of these hypotheses were supported with standardised coefficients *B*= - .72 (*p*<.001) and *B*=.84 (*p*<.001), respectively. It should be noted that all statistically significant effect sizes, except for the ones of country on CR and RC, were rather small, while all remaining hypotheses not discussed here are inconclusive due to a lack of statistically significant results.

Table 4.5-4 Regression Coefficients

Situation. Var.	***Gender***	***Age***	***Education***	***Income***	***H. Size***	***Spouse***	***Children***	***Country***
PR	- .168	.003	.090	- .034	.009	.035	.205	- .340**
IR	- .177	- .077	.070	- .037	- .039	.233	.248	- .167
CR	.337**	-.153**	.068	- .132	- .112	- .094	.154	- .716***
RC	- .177	.123**	- .030	- .001	.107	.122	- .116	.836***
SM	- .318**	.081	.085	- .022	.036	.159	.049	.262

N= 485
*** Coefficient is significant at the.01 level (2-tailed).*
**** Coefficient is significant at the.001 level (2-tailed).*
Notes: Problem Recognition (PR), Involvement Recognition (IR), Constraint Recognition, Referent Criterion (RC) and Situational Motivation (SM).

Source: Original work

4.6 Discussion

Our inquiry was based on the conceptualisation of Natech risk information deficiency as a cognitive meta-problem that individuals are called to address with respect to enhancing their preparedness against potential accidents. Thus, this study ventured to explore whether and how households' sociodemographic characteristics affected their situational perceptions and communicative attitudes. A series of multiple linear regression models were used in order to test the specified hypotheses to assess their validity. Out of the 40 hypotheses in total, only six evidenced statistically significant results that could warrant conclusions: in total, five hypotheses were confirmed, and one was rejected due to observing an inverse relationship.

Despite approaching the subject from a fresh perspective grounded in the public relations field, this study, essentially, did not contribute any radically new revelations with respect to the effects of sociodemographic determinants. Instead, our results resonated with the conclusions from previous risk perception studies in the context of Natech (Yu *et al.* 2017; Slack *et al.* 2020) and risk communication in general (Wachinger and Renn 2010; Wachinger *et al.* 2013): effects proved mostly weak and insignificant. In general, the cross-situational impotence of sociodemographic characteristics in comparison to the perceptual variables of STOPS (Grunig 1997; J.-N. Kim *et al.*

2009; 2012) was confirmed in this study. Nevertheless, our risk communication-oriented approach invites an interesting discussion about the findings.

Specifically, gender seemed to have a positive relationship with constraint recognition and a negative relationship with situational motivation for problem solving. As hypothesised based on the risk perception literature, males appear to be less motivated to communicate about the Natech risk information deficiency issue, while they perceive more obstacles in pursuit of information. Research has shown that males tend to underestimate risks in various contexts (*e.g.*, Savage 1993; Sund *et al*. 2017), and perhaps this reduced perceived severity of the initial chemical risk is what leads to a subsequently lower cognitive meta-problem appraisal and interest in a solution. This reasoning would explain the negative effect on situational motivation, as this factor is defined by problem, involvement and constraint recognition. Moreover, perhaps the comparatively lower interest of male respondents also magnifies the perceived limitations, simply because individuals have not invested themselves in analysing the issues in order to overcome them.

In terms of the effects of age, our findings seem to align more with the literature that regards age as a dampening factor for risk perception (Peacock *et al*. 2005; Huang *et al.* 2012). Along with age, there seems to come experience in how to resolve the meta-problem of Natech risk information deficiency. Older individuals appear to have more referent criteria readily available about how this problem should be handled. Following the conceptualisation of STOPS (J.-N. Kim and Krishna 2014), this may be due to more experiences accumulated over the years, as well as established expectations about how Natech risk information deficiency could be resolved. Of course, there is no established association between Natech risk perception and the communicative behaviour towards the issue of risk information deficiency, yet we could argue that the alleviating effects of reducing perceived limitations in resolving the meta-problem contribute in turn to lessening the perceived severity of the whole situation.

On the other hand, the variable of country demonstrated some interesting findings. Korean respondents appear to perceive themselves as less constrained in resolving the meta-problem of Natech risk information deficiency, whilst they have referent criteria they consider readily applicable to the issue. Results were strong and statistically significant in this regard. There even seems to be a positive, alleviating effect on problem recognition, although conclusions could not be statistically supported. Now, even though our methodological approach does not warrant a cross-cultural comparison at the national level between Japan and S. Korea, we included this factor in our analysis as a control for any underlying institutional parameters, particularly bearing in mind the difference in the chemical risk management regulatory frameworks of the two countries. Although we can only speculate at this point given these circumstantial findings, we

could entertain the idea that the recently introduced Chemical Controls Act, which includes chemical risk information disclosure provisions, actually succeeds in creating a more inviting chemical and Natech risk communication environment compared to Japan. Korean respondents seem to be more communicatively active towards resolving the issue of Natech risk information disclosure, and perhaps this is due to the existence of a regulatory environment.

Of course, the central point of our reasoning is a fairly similar, collectivistic organisational culture among the two countries (see *e.g.*, G. H. Hofstede 2001; House *et al*. 2004; G. Hofstede *et al*. 2010) that does not significantly skew the observed relationships. However, contemplating the arguments about the dissimilarities of the two organisational cultures (S. H. Kim and Kim 2016; Park *et al*. 2016), a *ceteris paribus* assumption for the sociocultural parameters at play cannot be upheld. Moreover, any conclusions based on the comparison between the Japanese and Korean sub-groups in our survey respondents must be treated with extra caution considering the sample discrepancies presented in the dataset. Furthermore, we cannot exclude any hidden factors we may have omitted or understated in our approach. Nevertheless, these preliminary results may pave the way for future research that will test more rigorously this argument against various cross-cultural influences.

4.7 Conclusions

Going beyond risk perception studies that have traditionally approached the relationship between risk communication and sociodemographic determinants through the psychometric and cultural theory paradigms, we borrowed the interpretative framework of STOPS to investigate situational variables instead. We framed the lack of Natech risk information as a cognitive meta-problem that stems from the original, underlying Natech accident risk. Individuals perceive this issue and, according to the purposeful communication narrative of STOPS, become motivated to communicate and overcome it. In this context, this study set to investigate the potential effects of sociodemographic factors in shaping individuals' situational perceptions and communicative behaviour concerning the issue of Natech risk information deficiency. We collected data from households near prominent industrial parks in Osaka and Kobe in Japan, and Yeosu, Suncheon, Gwangyang and Ulsan in S. Korea, to assess the effects of factors such as gender, age, household size, income and educational level. The results of our regression analysis indicated mostly weak and insignificant effects, except for gender and age that suggested negative and positive influences on individuals' communicative attitudes, respectively. The implications of the institutional differences between the two countries were also discussed within the sphere of chemical and Natech risk communication.

As one of the very few studies in the emerging field of Natech risk communication, we hope the findings of this research can contribute to formulating and focusing directions for further investigations. However, there are some drawbacks in this study that should be discussed here with an outlook to future research. There was no intention of conducting a cross-cultural study that would involve sociocultural constructs, and would focus on comparing the two samples, even at a national level. Arguably, our approach combined responses from individuals of different sociocultural backgrounds, and so introduced—inevitably—some culture-specific biases. We acknowledge that our efforts to address this issue with the introduction of a single control variable are far from optimal. In this respect, this research topic would greatly benefit from a full-fledged cross-cultural study that would incorporate sociocultural dimensions to effectively capture and disambiguate their influences on the situational variables. Moreover, as pointed out in the results section, we did not optimise our sampling method in pursuit of more representative population samples that would permit generalisations and a comparison at the national level between Japan and S. Korea. In contrast, we opted for rather technical criteria, targeting households under immediate risk from a potential Natech accident at the neighbouring industrial facility. Resource limitations did not permit the implementation of a sampling strategy that would simultaneously control for the location and the demographic profile of respondents, thus resulting in notable demographic discrepancies between the two samples. Hence, future studies are encouraged to investigate the topic using different sampling techniques based on demographic criteria (*e.g.*, stratified sampling), especially if aiming for inter-group comparisons. Finally, our study did not explore the potential influence of survey participation incentives on the quality of responses in an opinion questionnaire about disaster risk communication and perception. Although our study employed both data collection strategies (*i.e.*, incentives and not), one for each sample, our findings do not allow us to draw conclusions concerning this matter. Considering that participation incentives might, hypothetically, affect the representation of certain sub-groups within the sample and—by extension—their perceptions, additional research is needed to further investigate these issues.

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Chapter 5 EGNARIA: Raising Natech Risk Awareness through a Serious Gaming Approach

5.1 Introduction

Over the past two decades, the scientific community and international organisations have come to realise that disasters outcomes depend crucially upon the local socio-political, economic, environmental and stochastic processes involved, instead of being determined just by the hazard's intensity (UNISDR, 2015). Indeed, hazard type (e.g., floods, earthquakes, tsunamis, technological), hazard exposure and vulnerability are not equal for everyone (Wisner et al., 2004). The political and socioeconomic settings on which a hazard event unfolds play a key role in determining its consequences, and particularly so when considering the potential for technological events such chemical and Natech accidents. On the other hand, the same institutional factors decide community and individual rights to access natural, financial, health and information resources (Wisner et al., 2004). As Hansson et al. (2020) remarked, more often than not some of the most vulnerable communities to natural or man-made disasters are actually those less prepared for the risks because of restricted access to vital disaster information sources. This communication chasm between science-based risk assessment, disaster risk management (DRM) and disaster risk reduction (DRR) practices becomes increasingly important nowadays, while research in this direction has only started to address some of the emerging challenges, such as how to raise community awareness and improve disaster literacy (Solinska-Nowak et al., 2018; Gaillard & Mercer, 2013).

A promising solution to this risk communication challenge is the use of serious games. Serious gaming approaches have gained momentum in recent years as promising tools to support education and raise awareness about important issues, owing to their capacity of engaging people in a co-learning process (Pereira, Prada, & Paiva, 2015; Roncoli, 2006). A multitude of serious games with a particular focus on DRM have been developed lately. Several studies have attested the successful application of serious games as effective tools that enhance understanding of DRM activities, encourage participatory decision-making, promote information transmission and raise awareness (Solinska-Nowak et al., 2018; Taillandier & Adam, 2018; Mossoux et al., 2016; Pereira, Prada, & Paiva, 2015; Meesters, Olthof, & Walle, 2014).

While serious games have been developed considering various types of natural hazards, they rarely seem to incorporate technological hazards. In fact, a meta-analysis by Solinksa-Nowak et al. (2018) revealed that out of the 45 reviewed DRM-related serious games, the vast majority concerned natural hazards, namely floods (27), earthquakes (10) and droughts (7). While there

were a few games (7) that employed a less-structured methodology and could be potentially adapted to any hazard scenario, serious games that focused explicitly on technological hazards were surprisingly absent. In general, DRM-related serious games that take into account man-made hazards seem to be quite rare (e.g. one exception is *B-Safe!*; Cremers et al., 2015). Other researchers highlighted a general gap concerning DRM-related serious games that follow a multi-hazards paradigm and consider more than a single hazard at a time (de Ruiter, Couasnon, & Ward, 2021). Typically, such games tend to focus on individual natural hazards, such as coastal floods (e.g., *SPRITE*; Taillandier & Adam, 2018) or rainfall-induced flooding (e.g., *Battle of Flooding Protection*; Tsai et al., 2020) to name a few, or a specific hazard group (e.g., *Hazagora*; Mossoux et al., 2016) at best.

Even when serious games include groups of various hazards they do not account for the systemic view of complex hazards (de Ruiter, Couasnon, & Ward, 2021). For example, *Hazagora* incorporates earthquake, tsunami and volcanic hazards in a sequential fashion and, thus, omit any hazard interactions (Mossoux et al., 2016). *B-safe!* considers environmental and man-made hazards, but leaves out any links between DRR strategies (Cremers et al., 2015). United Nation's *Stop Disasters!* explores DRR strategies for hurricanes, earthquakes, tsunami, floods and wildfires through different game modes that play out independently (Pereira, Prada, & Paiva, 2015; Carvalho, 2014). The pioneering work of de Ruiter et al. (2021) attempted to address the challenge of multi-risk DRR management with the development of *Breaking the Silos*, although their particular focus was on enhancing the understanding of DRM practitioners about the complexities and potential (a)synergies involved in multi-hazard risk management.

Moreover, past DRM-related serious games have been criticised on the grounds of placing too much emphasis on the preparedness phase of the DRM cycle (Solinska-Nowak et al., 2018), with only few exceptions of role-playing games targeted at the emergency response phase (Terti et al., 2019). Furthermore, in order to reverse the still largely reactive DRM process (Mojtahedi & Oo, 2017), several studies underscored the importance of developing more gaming approaches based on multi-player collaboration (de Ruiter, Couasnon, & Ward, 2021; Gampell et al., 2020; Solinska-Nowak et al., 2018). Lastly, another significant limitation of previous DRM-related serious games revolves around the disproportionate emphasis on risk management strategies on financial aspects (de Ruiter, Couasnon, & Ward, 2021; Taillandier & Adam, 2018).

In light of the increased attention natural hazard-triggered technological accidents—referred to as 'Natech'—that involve the release of hazardous materials have received recently in both the academic (for a review see Suarez-Paba et al., 2019) and international policy arenas (see e.g., Addendum to the OECD Guiding Principles on Natech Risk Management; OECD, 2015), this

study ventures to address the above shortcomings of DRM-related serious games and contribute to filling a research gap in the emerging field of Natech risk communication by developing *EGNARIA: an Educational Game for Natech Risk Awareness*. *EGNARIA* is a novel, multi-player, role-playing board game designed to raise awareness about Natech accident risk, generate discussion around DRR strategies among various stakeholders (e.g., policymakers, DRM practitioners, researchers, so forth) and engage the community in the DRM process pertaining to Natech accidents. As the term 'Natech' implies (UNDRR-APSTAAG, 2020), this game particularly deals with conjoint hazard scenarios that involve chemical release accidents caused by the impact of earthquake and tsunami on industrial facilities. To the best of our knowledge, this is the first DRM-related serious game that addresses Natech accidents. Moreover, it emphasises the importance of chemical and Natech risk information disclosure as an essential element for the preparedness against such scenarios. In this respect, we build upon the interpretative framework of the Situational Theory of Problem Solving (STOPS) proposed by Kim and Grunig (2011) to develop an appropriate evaluation tool to assess the impact of *EGNARIA* from a risk communication perspective.

This chapter introduces *EGNARIA* and presents our insight regarding its educational impact. The rest of the chapter is organised as follows. First, we provide a brief review of the related academic discourse on DRM-related serious games, and then we elaborate on the structure and development of *EGNARIA*. Next, we present the trial application and game evaluation methods employed in this study. We proceed to discussing our preliminary findings, considering its limitations and future outlook.

5.2 Literature Review

Academics agree that distrust among stakeholders does not stem only from institutional frameworks ill-suited for addressing disaster risk. It is intrinsically related to the capacity of DRM practitioners—or rather lack thereof—to bring all involved stakeholders and stake-seekers, who usually operate at dissimilar scales and pursue different directions, together around the same discussion table (Gaillard & Mercer, 2013). Genuinely multi-stakeholder projects planned around the collaboration among local communities, scientists, local and national governments and NGOs are quite scarce in DRR literature (e.g., Fazey et al., 2010; Daly et al., 2010; Cronin, Gaylord, et al., 2004; Cronin, Petterson, et al., 2004). In spite of their innovative view and promising results, such projects seem to have encountered serious challenges in balancing power relationships between the involved stakeholders. As Gaillard and Mercer (2013) noted, these difficulties mostly resulted from the lack of communication tools which could be mutually trusted by all actors, facilitate knowledge-transfer and understanding and, ultimately, foster DRR dialogue.

Actually, most tools used by scientists and government management authorities to assess hazards and society vulnerabilities—community capacities are hardly ever considered—and to promote DRR fall within the realm of what Chambers (2007) calls *'economic reductionism'*. These methods are designed to appraise the so-called 'extra-ordinary dimension of hazards and disasters' (Gaillard & Mercer, 2013). For instance, hazard assessment in particular deals with minimising the inherent uncertainty involved in estimating the occurrence of natural events; therefore, specialised technical apparatus and elaborate mathematical simulations models are employed as dictated by the contemporary state of the art (Saito et al., 2012). In parallel, the work of social scientists is usually limited to evaluations of perceptions about risks and vulnerabilities based on semi-qualitative methods, such as questionnaire-based surveys or socio-spatial analyses using Geographic Information Systems. While such tools hold important merits for their niche applications, they are criticised as largely quantitative and context-insensitive approaches designed and imposed by 'outsiders' from the local community in order to apply global scientific standards (Gaillard & Mercer, 2013).

There is, however, a plethora of community-based DRR tools which are used predominantly by NGOs for facilitating the participation of local communities. Typically, these methods ascribe to the *Participatory Learning and Action (PLA)* paradigm (Abbot, 1999) and entail techniques such as ranking, scoring, calendars and timelines, problem trees, Venn diagrams, transect walks, participatory mapping, and so forth (Chakraborty et al., 2020; Gaillard & Mercer, 2013). Additionally, DRM practitioners have developed specific toolkits, such as *Vulnerability and Capacity Analysis (VCA)* matrixes that are now commonly used (see Anderson & Woodrow, 2019; CARE, 2019; Davis, Haghebeart, & Peppiatt, 2004). Unfortunately, whilst these tools have proven to be effective in achieving their primary goal of identifying local knowledges and critical issues and further supporting the planning of community actions at the local level, indeed they seem to fall short at integrating stakeholders and NGO partners from 'outside' (Gaillard & Mercer, 2013). In this respect, government institutions and researchers alike have been rather reluctant to seriously consider both the participatory tools themselves and the benefits of knowledge co-production they entail for improving DRR policies. This is unsurprising because participatory tools are not predominantly geared towards producing quantifiable and tangible data that are of primary importance for scientists and decision-makers (Gaillard & Mercer, 2013).

And yet, international organisations have delineated a clear path towards participatory risk governance as a paradigm to address societal risks. The Sustainability Development Goals (SDGs) (UN, 2015), for instance, advocate for enabling and actualising societal transformations to sustainable patterns of living at multiple temporal and spatial scales. In this vein, failure to discover

and realise viable strategies for transformations across spatial scales—global to local—poses daunting systemic risks to our society (Okada, Chabay, & Renn, 2018; Webb et al., 2018; Nanz, Renn, & Lawrence, 2017; Sharpe et al., 2016; Renn, 2016). In order to address such challenges, Okada et al. (2018) propose the development and application of new tools and methods for adaptive and participatory risk governance; that is the advancement of *'implementation science'*. Implementation science is conceptualised as *'a sustained, adaptive, and synergetic coproduction of knowledge and codesign of contextually-appropriate solutions'* (Okada, Chabay, & Renn, 2018, p. 431). They note that engaging with and incorporating representatives from an inclusive social spectrum is the cornerstone of an adaptive risk governance process. This view is closely linked with the concept of transdisciplinary research with the added emphasis on co-production of knowledge and solutions (Caniglia et al., 2017). Thus, implementation science offers a methodological framework for pursuing and actualising transdisciplinary and transformative DRM research (Okada, Chabay, & Renn, 2018).

In the above context, scholars highlight the importance of establishing and promoting community-based activities, which function as *'communicative spaces'* (Okada, 2021) or *'boundary objects'* (Chabay, 2018) that create a co-learning environment, enable stakeholder interaction and discussion and invite communities to become actively involved in the risk-related decision-making processes. Moreover, community challenges for implementing DRR activities can seem overwhelming for communities with relatively little resources, which more often than not leads to loss of community interest in the DRM process and stakeholder 'paralysis' overall. In order to overcome this issue Okada (2018) advocates starting from small-scale community initiatives and progressively scaling-up in an effort to activate communities and gradually build stakeholder interest, a process he described as the *'Zero-to-One Movement'*. This adaptive risk governance scheme has been successfully applied in Japan to introduce local communities to DRM and pursue transformative change (Okada, 2018).

Methods, such as serious gaming, that engage all DRM actors hold particular value for risk communication. Considering the Japanese reality, Yamaguchi et al. (2018) underscored that the role risk communicators is to build bridges between risk managers, risk assessment experts and related scientists, and other key stakeholders, such as citizens and consumers. Crucially important in this process is the translation and communication of risk-related information into understandable information, taking into account matters of literacy and accessibility of various social groups (Kinchy & Schaffer, 2018; Yamaguchi et al., 2018). In parallel, risk communicators should establish a rapport with community representatives in order to collect feedback and understand public concerns and changes in values and priorities along the process. This interactive

and bidirectional communication process between communities and disaster risk managers is of paramount importance (Renn & Klinke, 2013). Confirming past studies in various other sociocultural contexts, evidence from Japan also seemed to indicate that serious gaming is a viable and effective approach for health and disaster risk communication, especially when intended to familiarise broader audiences with complex technical aspects, such as radiological risks (Yamaguchi et al., 2018).

Furthermore, the '*normative*' imperative of disaster risk communication, as introduced by Fiorino (1990), is based on the premise that communicating about the risk is '*the right thing to do*'. In this regard, communication is understood as an ethical practice that aims at creating a level playing field for all stakeholders and stake-seekers in DRM in order to facilitate risk-informed decision-making (Wardman, 2008). Access to risk information is seen as a public right, while risk-related decisions are the outcome of a democratic community deliberation that is based on meaningful and two-way/symmetrical risk communication practices (Grunig, 2018; Ni et al., 2015). In parallel, the '*substantive*' imperative dictates that risk communication should improve the understanding of all actors and provide the foundation for the public discussion of risk-related decisions. Emphasis is placed on the plurality and representation of stakeholders' views, conflict resolution and consensus-building through communication (Wardman, 2008).

The above arguments have important implications for Natech risk communication because it revolves around the sensitive subject of chemical risk information disclosure. The inherent interdependencies and uncertainty that characterise Natech accidents, along with their large-scale impact, present enormous challenges for risk managers (Eisner, 2014). Shimizu and Clark (2019) note that complex disasters, such as these, demand for inclusive and multidimensional responses that engage actors from the government, business and local community for the purpose of addressing the associated risk effectively. This warrants a *substantive* risk communication approach. Moreover, given the evidence suggesting that communities are indeed motivated to engage in Natech risk communication and have an 'appetite' for risk information disclosure (see Chapter 3 of this dissertation), risk communication strategies are invited to adhere to a *normative* approach. Taken together, Natech risk communication ought to adhere to a '*risk dialogue*' paradigm, following Wardman's (2008) categorisation, in hopes of being effective. In a risk dialogue risk communication model, actors are considered as equals and treated like partners, empowering them with greater agency to influence how risks are managed and allowing them to exchange information and opinions concerning what has been learned about them in order to make a substantive contribution to the public risk debate (Wardman, 2008; Fischhoff, 2005).

Nowadays there is a wide recognition that DRR has evolved past the understanding and mitigation of hazards, to involve strategies that focus on community capacity-building and resilience (Mossoux et al., 2016; Smith, 2013). Indeed, this is set as one of the priority areas for the Sendai-Framework for Disaster Risk Reduction (UNISDR, 2015). In this context, communication approaches that emphasise motivation and engagement, such as serious gaming, have come to the forefront (Ormrod, 2008) and are now widely accredited as potent methods in the field of disaster risk communication as well (Gampell et al., 2020; Solinska-Nowak et al., 2018; Yamori, 2009, 2012).

Serious or *applied games* are not designed for pure entertainment purposes, but rather to achieve specific learning objectives or provide an engaging environment that fosters skill development and behavioural change (Zhonggen, 2019; M.Nazry & Romano, 2017; Boyle, Connolly, & Hainey, 2011). According to the definition offered by Abt (1987), serious games *'have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement'*, although this *'does not mean that serious games are not, or should not be, entertaining'*. Central to the idea of serious gaming is the concept of *experiential learning* (Kolb, 2014). This learning mechanism refers to the transformation of the experience an individual is immersed in into knowledge. In this vein, learning about a new subject requires the individual's exposure to processes that involve it (Kolb, 2014). The processes themselves need to engage learners and keep the motivated throughout by including surprises and challenges along the way (Mossoux et al., 2016; Pereira, Prada, & Paiva, 2015; Bogost, 2008).

Serious gaming holds important advantages considering the learning process explained above. Learning through games is based on heuristic mechanisms (Mossoux et al., 2016; Kolb, 2014). Players are presented with the opportunity to experience complex situations through vivid and immersive scenarios with which they can interact. In these alternative realities, players can experiment and test various solutions to the presented problems without having deal with the actual negative consequences in real life (Solinska-Nowak et al., 2018; Lamarque et al., 2013). This feature is extremely important with respect to crises that may have a significant and large-scale impact on economic and human activities or even be life-threatening, such as disasters. Concerning DRM, the recently growing academic research has underscored that serious games indeed have the potential to reach out to a wide audience and convey reliable and consistent disaster-related information, increasing risk awareness and understanding about hazards and vulnerabilities, and teaching useful skills for every phase of the disaster risk management cycle (Solinska-Nowak et al., 2018).

The relaxed and fun environment created via gameplay can also contribute to reducing the levels of anxiety for learners and encourage communication and debate among participants (Mossoux et al., 2016; Clerveaux, Spence, & Katada, 2010; Clerveaux & Spence, 2009). Such conditions have been found to promote knowledge-sharing and collaborative decision-making as players try to compete and/or cooperate within the game to explore new strategies. Moreover, scholars noted that face-to-face role-playing games provide a great opportunity for *multilogue* (Duke, 1974): that is creating an inducive environment for communication and collaborative decision-making (Yamori, 2008). Using interactive methods for communication encourages intuitive, hands-on and experiential learning which has been linked with effective information retaining (Solinska-Nowak et al., 2018; Bogost, 2008).`

Participatory DRM workshops and serious gaming methods are certainly not new in Japan. Previously successfully applied examples of such tools include workshop activities, such as the *Yonmenkaigi System Method (YSM)* (Okada et al., 2013), evacuation shelter management exercises (Tsubokawa, Nagasaka, & Usuda, 2008), and community-based training programmes for post-disaster recovery (Ichiko et al., 2005), as well as serious gaming, such as *Crossroads: Kobe* (Kikkawa, 2014; Yamori, 2009, 2012; Kikkawa et al., 2004) and the *Disaster Imagination Game (DIG)* (Komura, 2004). With the exception of the *YSM*, the abovementioned participatory DRM tools have been criticised for concentrating primarily on exploring personal capacities and individual decision-making processes for DRR action plans rather than placing emphasis on truly community-based collaborative action planning (Okada et al., 2013; Na, Okada, & Fang, 2008). While acknowledging the merits of enhancing individual disaster preparedness, Okada et al. (2013) remark that group-led decision-making methods aimed at promoting and implementing participatory DRM are still lacking in the Japanese scene. The adaptation of the YSM method was an effort in filling this gap in DRR research and practice, focusing on proactive disaster mitigation and prevention planning, while their findings underscored the importance of further research in this direction.

5.3 Game Description and Development

As still an emerging topic in DRM research, Natech risk management has only recently started gaining academic interest. Scholars have highlighted the significance of Natech risk communication as an essential aspect in view of minimising societal risk and further engaging potentially affected communities in the risk-related decision-making about its management (Suarez-Paba et al., 2020). Nonetheless, recent literature reviews in the field of Natech risk management (Suarez-Paba et al., 2019) noted a research gap in risk communication and invited future studies to tackle the challenge of expanding our understanding and developing tools for Natech risk communication (Cruz & Suarez-Paba, 2019).

Answering this call for Natech risk communication, this study proposes a novel, face-to-face, role-playing board game, *EGNARIA: an **E**ducational **G**ame for **NA**tech **RI**sk **A**wareness*. To the best of our knowledge, *EGNARIA* is the first serious game specifically designed to explore and communicate the complexities of Natech accidents. The game's purpose is to raise community awareness about Natech accidents, and generate a discussion among all stakeholders pertaining to risk management strategies, chemical information disclosure and collaborative, risk-informed decision-making concerning Natech accidents. From a risk governance perspective, *EGNARIA* is aimed at framing and fostering community participation in the context of Natech risk management, and furthermore emphasising the importance of access to chemical risk information as a prerequisite for participatory DRM considering Natech accidents. *EGNARIA* is a *persuasive game*[16] by design (Jacobs, 2018; Bogost, 2007) that tries to highlight the need for community engagement and chemical risk communication for Natech risk management. Envisioned as an inclusive and collaborative Natech risk communication tool, *EGNARIA* is intended to be used in a community setting by all stakeholders and stake-seekers in the Natech risk management process; for example, it can provide a framework for multi-stakeholder workshops including risk management researchers and practitioners, policymakers, industry managers, community leaders and citizens.

EGNARIA draws inspiration from previously developed disaster education games for a few of its game elements. The most influential serious games were: *Hazagora: will you survive the next disaster*, developed by Mossoux et al. (2016) and the '*Bōsai Game*' (transl. '*Disaster Preparedness Game*'), previously developed by the Disaster Risk Management Laboratory of Kyoto University's Disaster Prevention Research Institute (The Yomiuri Shimbun, 2015). However, it should be noted that the combination of such individual elements is introduced in a completely new context characterised by the Natech accident risk. In this sense, *EGNARIA*, adapts and synthesises various effective game mechanics in its design, utilising them as foundation upon which new game elements and mechanics specific to Natech have been developed.

[16] Bogost (2007) coined the term 'persuasive game' to describe a subset of serious games that 'mount procedural rhetoric' by embedding a message into their systems and game rules with the intention of changing or reinforcing certain attitudes.

Figure 5.3-1 Game Development

Source: Original work

The development process was interactive and iterative. During its development phase, trials with Kyoto University (Japan) researchers specialising in DRM and knowledgeable about Natech accidents provided valuable feedback and directions for improvement. In total, five such *alpha*-test sessions over five different game maturity stages were conducted (Figure 5.3-1). After the game had reached a satisfactory stage, a *beta*-test session was organised with graduate and post-graduate engineering students of Osaka University (Japan), who were mostly unfamiliar with the concept of Natech accidents. After incorporating their feedback in the design elements and presentation of the game, we determined that an acceptable game state had been achieved, which would allow us to hold a game session and evaluate *EGNARIA*'s impact as a Natech risk communication tool.

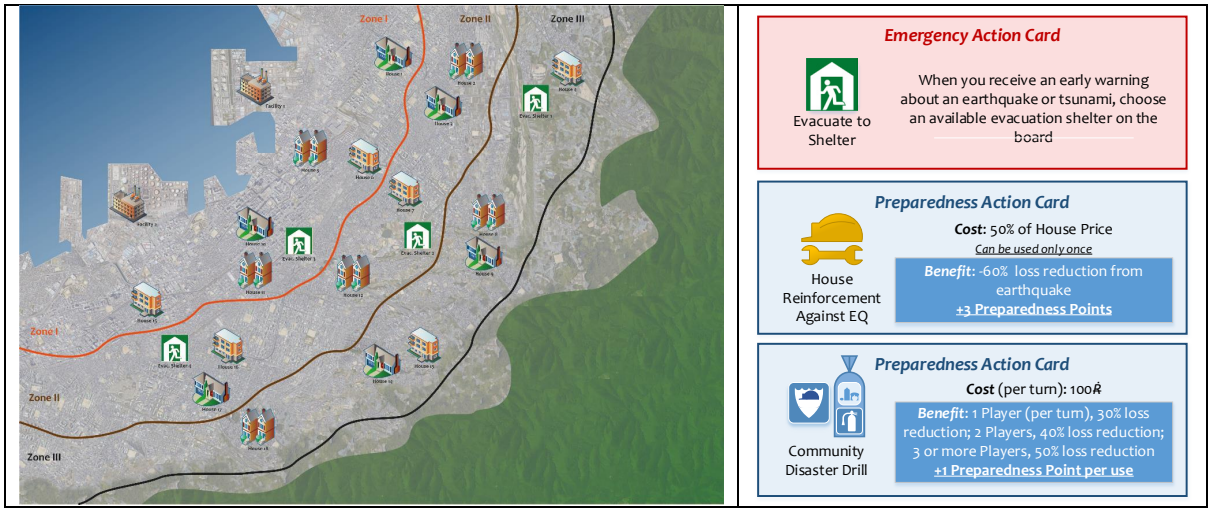
5.3.1 Game Objective

EGNARIA is set in a coastal, industrial city that is affected regularly by earthquake and tsunami. The goal of the game is to survive the disasters by becoming better informed and prepared, while keeping the support of other players in the process. Players are citizens that vote for a community leader and an industry manager among them. They try to manage their available resources, both individually and as a community, considering disaster preparedness actions with the aim of mitigating the impact or protecting themselves and their properties from the natural hazards and the various chemical accident scenarios. Players earn points by spending resources to make decisions that improve their disaster preparedness and lose them if they become directly exposed to the natural hazards and/or their consequent chemical accidents. The player with the most preparedness points at the end of a set number of turns is crowned the winner.

5.3.2 Game Rules and Setup

The game can be played by up to 18 individual players, while participants are not discouraged from forming small groups (e.g., two persons) and deliberate among themselves about their assigned character's actions. Also, while there is no explicit age restriction, the game is recommended for cognitively mature players (e.g., of at least 15 years old) due to the inherent complex and systemic nature of Natech accidents. Gameplay length is recommended to be about 3-5 full rounds of the game which is estimated to take around 2 to 3-hours in total (including debriefing session afterwards). *EGNARIA* is led by a game master who is in charge of monetary transactions, guides participants through the different stages in each round and adjusts the natural hazard frequency/intensity following the game's instructions. The game materials consist of: one *EGNARIA* gameplay manual, one (1) gameboard, eighteen (18) unique house cards, six (6) chemical release scenario maps, two (2) chemical risk assessment maps, two (2) citizen preparedness action cards for each player, two (2) emergency action cards for each player, three (3) Natech preparedness cards for each player, four (4) industry manager action cards, four (4) community leader action cards, game currency, hazard cards, point tokens and dice (Figure 5.3-2).

Figure 5.3-2 Gameboard and Materials



Source: Original work

Bearing in mind that the game is intended to represent actual conditions from an abstract and simplified perspective, the gameboard features the imaginary coastal city of *Egnaria*. This area is prone to earthquakes and tsunami, and so it is divided into three tsunami inundation zones visible to all players (Figure 5.3-2). Two industrial facilities handling potentially hazardous materials are situated in two separate locations along the coast. Moreover, there are 18 different house locations depicted on the gameboard. The houses are categorised into three building types, namely traditional townhouses, detached houses and apartments, and are distributed in pairs—

but in random locations—within each tsunami inundation zone. Each house has a unique profile depending on its age, condition, nearby amenities, and transportation access and—of course—location that is reflected on the initial house buying cost, revenue generation and living costs. The categories that influenced house characteristics were derived based on research on people's perceptions about residential property value (Wittowsky et al., 2020). Finally, there are four evacuation shelters that spread across different areas of the city.

The imaginary in-game currency is called *Rin* (Ṙ) and is used by players as a financial resource that can be exchanged for various actions throughout the course of the game. In this way, players are forced to plan ahead about how they spend their resources and what DRR strategies best suit their needs individually and as a community. During the setup stage of the game, players are given 1,000Ṙ to buy the house of their choosing considering the information available on the house cards themselves and the gameboard the shows only the tsunami inundation zones; none of the players have any information pertaining to chemical accidents at this stage.

Figure 5.3-3 Game Setup

Source: Original work

After the initial house allocation (Figure 5.3-3), players are asked to discuss/vote/roll dice to decide who wants to assume the additional role of the '*community leader*' and that of the '*industry manager*'. These two roles cannot be undertaken by the same player and are supplementary to their main game role as '*citizens*' of *Egnaria*. It is explained at the start of the game that the roles of '*community leader*' and '*industry manager*' are not permanent throughout the game and can be passed on to other players at the end of each round via a vote. *EGNARIA* is a round-based game, with each round representing one decade in real-life. With the exception of the starting 'warm-up' round, each round has a consistent sequence of phases: (i) determining player income, (ii) determining what—if any—disaster occurs, (iii) estimating damages, (iv) deliberating about personal and collective investments and (v) finally vote of confidence. As a rule, no natural

hazard occurs during the 'warm-up' round in order to familiarise players with the game mechanics and allow for resource accumulation in order to invest in preparedness measures later on.

As previously mentioned, game progress is based on a point system in which players earn points by spending their resources for preparedness actions. Instead of focusing only on minimising the economic impact from natural hazards and later on by chemical accidents, players are nudged to collect points by exchanging resources for actions that improve their disaster preparedness against Natech accidents. Each citizen is given two (2) preparedness action cards and two (2) emergency action cards. Preparedness action cards cost players a certain amount of *Rin* (Ṙ) and allow them, for example, to reinforce their house against earthquake or take part in emergency drills and community disaster preparedness activities. Depending on the action, players are awarded points by using these cards. On the other hand, emergency action cards are free but can be used only in the case of a natural hazard event. Players are asked to decide if they wish to shelter-in-place or evacuate to a nearby shelter of their selection. If a player becomes directly exposed to a natural hazard and/or accident, they lose points. Bankruptcy is also incorporated in the game via point deduction, but does not mean 'game over' for the player that suffered it.

5.3.3 Playing the Game

EGNARIA actually begins at the setup stage when players are asked to invest their initial 1,000Ṙ to purchase a house. Players are initially confronted with a situation characterised by the complete absence of chemical risk information. According to their subjective judgement and armed only with the information that *EGNARIA* is a disaster-related game, players are asked to choose a house based on the location and the aforementioned house profiles. It is noteworthy that players cannot change their house locations for the rest of the game after this starting stage. Lastly, the '*industry manager*' is asked to choose which of the two facilities on the gameboard handles toxic chemicals and which flammable. They are then asked to keep this information to themselves under the threat of a severe economic penalty, unless they use the designated risk information disclosure cards during the course of the game.

After the initial house choice and the allocation of the additional '*community leader*' and '*industry manager*' roles, the 'warm-up' round can begin. In an attempt to simulate financial resource variability, we have introduced the element of probability in determining the players' income in each round. First, all players are asked as *Egnaria* '*citizens*' to roll the dice in order to determine their individual income for this round. House revenues depend on the house location, building type and nearby amenities. Next, the '*industry manager*' is asked to roll the dice to determine the industry income for this round. Conceptualising *Egnaria* as a closed and

oversimplified economic system, community income is calculated as a percentage of the total industry income for this round.

With all the starting round incomes calculated, a deliberation phase can begin about investment decisions. Players are invited to share their opinions about how community money should be spent, i.e., what type of preparedness actions and where. All players and roles are invited to participate in this discussion. The *'industry manager'* is responsible for managing the industry's available resources, while the *'community leader'* is in charge of investing—or not—the community resources for this round. In parallel, all players are asked to discuss and decide on their individual investment choices as *'citizens'* of *Egnaria*. Of course, players in all roles can choose to take no action for this round. In any case, at the end of the investment deliberation phase the corresponding fees are collected from the *'industry manager'*, the *'community leader'* and all the *'citizens'* and the respective points are awarded to players accordingly.

Following the closing of the investment deliberation phase (about 10 to 15min in length), a quick voting takes place (less than 3min). The *'industry manager'*, the *'community leader'* are judged based on their decisions for this round. All *'citizens'*—save for the player that is being judged—are asked whether they give their confidence vote (e.g., 'please raise your hand if you support…'); a simple majority vote system is implemented where *'community leader'* break potential ties. In the case that the *'industry manager'* is downvoted, the role is then re-assigned to a different player (volunteer/vote/roll dice). If the *'industry manager'* receives the support from the community, remains in this role for the next round and also receives extra a small industry revenue in the following round. For *'community leader'*, the process is similar. If they receive the community's vote of confidence, they remain in their role. If not, they change and receive a negative reputation point (deducted from the preparedness points at the end of the game). In this respect, players that act as *'community leaders'* are discouraged from disregarding community's opinions during the investment phase, as they risk being downvoted afterwards; thus, players are confronted with compromises and consensus-building challenges. The *'community leader'* role becomes available to be assigned to a different player via a majority vote for the upcoming round. This concludes the 'warm-up' round.

This process is repeated in this order in subsequent rounds and until the end of the game, with the only addition of a disaster determination step and a following damage assessment step immediately after the income determination step. If a natural hazard or a Natech accident occurs, the players are asked to consider their investments, given the resource deductions after the damages they have suffered (explained next).

5.3.4 Natech Accidents

Natech accidents are conjoint events of chemical accidents caused by a natural hazard. Therefore, they involve two distinct, yet interconnected elements: the natural hazard and the chemical accident conditional to it. In order to incorporate this aspect into the game—while remaining remotely realistic—we decided to introduce a two-step process that offers some control over the occurrence and intensity of the natural hazards, but also involves randomness in determining the chemical scenarios. As mentioned earlier, the game—in its current version—deals with earthquake and tsunami hazards, each of which has three intensity levels. Earthquakes are assumed to affect all locations on the gameboard uniformly, while tsunami inundation is dependent upon the hazard intensity level. Chemical accident scenarios include toxic gas clouds and explosions, but—for the sake of simplicity—do not consider intensity levels. However, for toxic gas, different dispersion scenarios affect different parts of the city, while for flammable materials, there are only two possible scenarios: explosion with a huge area of effect or no explosion. The game is recommended to be played for 3 to 5 rounds in order allow players to experience different hazard scenarios.

From the second round (after the 'warm-up' round) onwards, after the income determination phase, the game master selects a number (e.g., 5 to 10) of natural hazard cards. There are three categories: (i) '*earthquake*', (ii) '*tsunami*', and (iii) '*safe*' (i.e., no hazard) cards. Depending on how '(un)fortunate' players were in the previous round with their incomes, the game master can 'adjust' the probability of occurrence (e.g., by selecting less '*safe*' cards in the set) and the probability of higher-intensity natural hazards (e.g., by leaving intensity level 1 cards out of the set). After compiling the card set for this round, they present the cards face down and ask a player to draw one card. Depending on the card, the occurrence—or not—of a natural hazard, as well as its intensity level is determined for this round. In the event of a natural hazard, the game master provides an 'early warning' by announcing the hazard type and intensity and asks '*citizens*' to decide their emergency actions quickly, following the corresponding instructions on the cards. If evacuation is selected, the game master asks them to indicate their choice (from the available nearby shelters) and remember it. The impacts of the natural hazard on '*citizens*' and their properties are determined in economic terms based on estimated damages tables at the back of each house card, and are dependent upon hazard intensity and previously implemented preparedness actions. Players are invited to estimate their own damages in order to reflect on the hazard scenarios.

Conditional to the occurrence of an earthquake or a tsunami, the game master requests one of the players to roll a die to determine whether there was a chemical release at the first

industrial facility. Probabilities for loss of containment depend upon the natural hazard intensity and the availability of mitigation and prevention measures at the facility in question. The same procedure is repeated for the second facility to determine whether there has been a chemical release. It should be noted that intensity level 3 natural hazards always cause a chemical release at both industrial facilities, as a game mechanic that simulates a beyond-design-basis event, such as the Fukushima Dai-ichi accident (Kim et al., 2016). In case of a chemical release (i.e., rolled number exceeds predetermined game thresholds), the game master asks for another die roll to determine the chemical accident scenario. As far as the toxic cloud is concerned, there are three possible scenarios that simulate wind conditions: (i) no dispersion over *Egnaria*, (ii) area A (or C depending on the facility) is affected, and (iii) area B (or D depending on the facility) is affected. For releases of flammable materials, the additional die roll determines whether there is an explosion or not. All areas described in the above scenarios are predetermined and assumed to impact '*citizens*' equally regardless of location for simplicity. Depending on the chemical accident scenarios and '*citizens*'' evacuation choices and previously implemented preparedness measures, each players exposure—or not—to the chemical hazard is determined. The areas affected by the chemical accident are visually represented as coloured zones on the gameboard map, and players are asked to reflect on whether the actualised chemical accident scenario affects them or not. If a player is affected by the chemical accident, they receive negative, 'hazard exposure' points. Finally, economic damages from the natural hazard on the industrial facilities are deducted by the industry's income, the cost depends on: (i) the natural hazard intensity, (ii) whether there has been a chemical release at any of the facilities, and (iii) whether chemical information has been disclosed in the previous round.

5.3.5 Protective Actions

The '*community leader*' is in charge of deciding at the end of the deliberation phase on which—if any—preparedness action(s) they want to invest the community's resources. They can choose to 'upgrade' an evacuation shelter for one round (i.e., until the investment deliberation phase of the next round) by: (i) equipping it with protective gear for a toxic gas release, (ii) reinforcing it against explosions, or (iii) both. These upgraded shelters offer special protection to the evacuees against the respective chemical hazards for this round.

The '*industry manager*' on the other hand, has to decide whether they want to: (i) expand their facilities (indicate which one) so as to increase their revenue from the next round onwards; (ii) invest in reinforcing accident prevention and mitigation measures; or (iii) invest in chemical risk communication. Chemical risk communication comes in two levels. At the basic level, information about what kind of chemicals (i.e., toxic/flammable) are handled in which facility is disclosed to the rest of the players. At the advanced level, chemical risk assessment maps are made available to all

players. We should mention here that, as a leverage point for the community over the industry decisions, the *'community leader'* has the option of imposing a decent financial penalty for this round, if the *'industry manager'* has not disclosed any chemical information. It should be noted that investments in preparedness measures that benefit the whole community (e.g., chemical information disclosure) are rewarded collectively by awarding all players equally with preparedness points.

The available options for *'citizens'* also depend on the course of the game. Initially, they can either: (i) reinforce their house against earthquake, or (ii) invest in community disaster drills. The latter option has increased merits by reducing the economic impact of natural hazards the more players use it in the same round. This mechanism incentivises players to invest in community preparedness actions collaboratively, and thus fosters coordination and consensus-building during the deliberation phase. If the *'industry manager'* has invested in Natech risk assessment, then a third preparedness action becomes available for all *'citizens'*: Natech response training. In turn, there are three options that include preparedness against: (i) toxic chemicals, (ii) flammable, or (iii) both. In case of a natural hazard, all players as *Egnaria 'citizens'* are asked to indicate their emergency response action, choosing between: (i) 'sheltering-in-place' or (ii) 'shelter evacuation'. Their choice essentially affects their location and available means for protection, thus determining whether they become affected by a subsequent chemical accident.

5.3.6 Game Outcome

The winner of the game is decided by comparing the sum of points each player has gathered from all the rounds. The point system of *EGNARIA* is designed in such a way to emphasise the value of collaboratively managing limited resources in the context of DRM and taking actions in advance to prepare against potential Natech accidents. Investing in preparedness actions that benefit the whole community is rewarded, either directly through awarding points to all players, or indirectly by mitigating economic damages that in turn minimises the risk of bankruptcy which would potentially cost them preparedness points. In addition to earning points after investing in 'good' preparedness practices, it is important to note that players can also lose them, if they are affected by chemical accidents, suffer bankruptcy or—in the case of the *'community leader'*—lose community trust.

Players are told in the beginning that the goal is to earn enough points in order to 'survive' and win the game. Whilst this imparts an interesting competitive aspect to the game driving players to collect the most points, it also serves as a criterion for evaluating disaster preparedness at the end of the game. A negative point score would imply that the player was not prepared enough to weather the storm against the Natech accident risk; a positive that their strategy paid

off. Naturally, the point system is designed so that all players, regardless of whether or not they have an additional role sometime throughout the game, have a fair chance of winning. On the other hand, due to the randomness introduced at the income determination step and incorporated in the Natech accident determination procedure, player tactics are not the only factor that determines the game outcome. From our perspective, this aspect aptly reflects the inherent uncertainty involved in Natech risk assessment and offers an interesting point for player discussion during the debriefing session.

5.4 Trial Application and Evaluation Method

Although the original intention was to hold a multi-stakeholder workshop in order to test the impact of the serious game with community members, due to COVID-19 restrictions, this did not prove feasible. Instead, the trial application of *EGNARIA* was conducted in November 2021 with a group of Kyoto University affiliates (Figure 5.4-1). A convenience sampling method was employed[17], according to which open invitations were sent to university graduate students and researchers in other than disaster-related fields of study. Participants received a small financial compensation in the form of a gift-card for their participation. The outline of the workshop involved an introduction of the game, a full 2-hour game session, and a follow-up debriefing/discussion session (Table 5.4-1). Our 2-hour session was originally planned so as to minimise participant fatigue, and allow them to play at least three (3) full game rounds, the minimum recommended number of turns. The workshop was run by one (1) main facilitator, who took on the role of game master during the game session, and one (1) additional assistant.

Table 5.4-1 Workshop Programme

Friday, 5th November 2021	
12:30-12:45	*Introduction*
12:45-14:30	*Game Session*
19:00-19:30	*Short discussion*

Source: Original work

Our research approach followed a quasi-experimental design for the evaluation of the game's impact; workshop participants were asked to fill in a survey questionnaire before and after the game session. The sample consisted of nine (9) participants in total (6 female), relatively young (20-49 years old), mainly university students and researchers (Bachelor–PhD level) and mostly

[17] Similar method to previous DRM-related serious game evaluations (see e.g., Mossoux et al., 2016; Cremers et al., 2015; Pereira, Prada, & Paiva, 2015).

single (only 3 married). It is noteworthy that the group was quite multi-cultural (China, Taiwan, Myanmar, Germany, Japan, Indonesia, Kenya, Fiji).

Figure 5.4-1 Trial Game Application

Source: Original work

In view of the general lack of standardised evaluation criteria for the impact of DRM-related serious games (for a discussion see Solinska-Nowak et al., 2018), instead of simply proposing *ad hoc* measures we explored the opportunity of already available conceptual models that could provide a research framework for our purposes. Considering our particular emphasis on risk communication and information disclosure, and with the aim of understanding the *EGNARIA*'s impact on the players' communication behaviour regarding Natech risk, we structured our survey based on dimensions from the interpretative framework of the Situational Theory of Problem Solving (STOPS) (Kim & Grunig, 2011).

Based on this interpretative framework (Kim & Krishna, 2014; Kim & Grunig, 2011), an individual's perception of the problematic situation concerning the lack of Natech risk information (i.e., problem recognition), their perceived connection with it (i.e., involvement recognition) and the perceived obstacles which limit their ability to take action (i.e., constraint recognition), consist of the key factors of their situational motivation to engage in problem-solving communication. Along with any potential subjective knowledge, experiences and expectations (i.e., referent criteria), this situational motivation determines the individual's engagement in communicative action as a means to seek out and exchange information to resolve this issue. In turn, this communicative behaviour is categorised in three types of actions, information acquisition, information selection and information transmission, each of which has an active and a passive component.

The main part of the survey was structured based on STOPS measures. At least three items per STOPS latent construct were included, while the wording of the questions was based on measurement items tested and validated in previous applications of STOPS (Chen, Hung-Baesecke,

& Kim, 2017; Kim et al., 2012) with small adjustments to reflect the Natech risk context where needed. Concerning the 'game' aspect, we included an additional set of questions targeted at evaluating the *EGNARIA*'s game design based on the *world of Play*, measuring in particular the aspects of *Fun* (Isbister & Schaffer, 2008), *Engagement* (Calleja, 2011) and *Immersion* (Murray, 1997). Moreover, auxiliary questionnaire items were incorporated in an attempt to detect any change on players' perceptions about the importance of information and levels of Natech risk awareness.

A seven-point Likert-type scale ranging from 1 = 'Strongly Disagree' to 7 = 'Strongly Agree' was used to code the responses. The survey was developed and administered in English and in electronic format. The questionnaire included 62 questions for the pre-game version and 68 for the post-game, while it took between 20-30 minutes to complete. Respondents were asked in the pre-game questionnaire to write a unique secret code, that had to later be filled in the post-game questionnaire; this method allowed researchers to track responders without compromising participants' anonymity. A series of paired samples t-tests were conducted where available to identify statistically significant changes in responses before and after the game session. Apart from the questionnaire, after the completion of the workshop, an online debriefing session was also held. During the debriefing session the participants' overall impressions of the game were discussed, as well as potential improvements for future consideration.

5.5 Evaluating the Impact of the Game

To evaluate *EGNARIA*'s impact as DRM-related serious game we analysed four (4) key aspects, aside from examining the players' in-game strategies. First, we were interested in learning if the game contributed to any changes in intended communicative behaviour about Natech accidents, and then assessed if there were any differences in the players' Natech risk awareness, perceptions about Natech accidents, and impressions about Natech risk information. The preliminary findings presented here are based on the questionnaire survey results, but are additionally enriched with the points raised during the post-game discussion. Likewise, the overall players' impressions of the game are drawn from a combination of the opinions expressed during the workshop and a few questionnaire items.

5.5.1 Player Strategies

Players did not seem to concern themselves about potential chemical accidents at the beginning of the game. During the house allocation phase, they primarily concentrated on choosing a suitable house that stroke a balance between providing a consistently high income and —given the frequent tsunami threat—being at a safe distance from the coastline. Players started gradually thinking about chemical accident risk through the first investment deliberation step,

when they had to consider whether and how they wanted to spend community resources to 'upgrade' the evacuation shelters. Seeing that in case of a natural hazard, each of the evacuation shelters only accommodated a small area around them, arguments about investments essentially revolved around deciding where to allocate the limited resources to best serve the whole community of *Egnaria*. Another noteworthy obstacle they faced was the complete lack of chemical information, which in turn significantly limited their decision-making about the type of shelter 'upgrade' they should invest in for that round.

Moreover, many '*citizens*' contemplated the benefits of investing collectively in community preparedness drills to enjoy the increased damage reductions in case of a natural hazard event. This came to no surprise, as it was the cheapest available investment for them that awarded them with a point. Nevertheless, players debated the opportunity costs and tried to coordinate with other '*citizens*' to participate jointly in community preparedness drills for the additional damage reduction advantages. On the other hand, a few players exhibited a more risk-prone behaviour and decided to pass on preparedness investments in the first round in anticipation of not being affected by a hazard initially and also in order to have more resources in the beginning of the next round. The '*industry manager*' participated modestly in the initial discussion, given the limited financial resources and the considerably high investment cost their options had in that round. On the other hand, the '*community leader*' asserted a leading role during the deliberation process and felt the need to explicitly clarify and justify their position with respect to the investment of community resources. Arguably, such a transparent risk governance approach is rather far from realistic conditions.

The discussions changed drastically after experiencing the first natural hazard, which resulted in a toxic gas release. Thanks to fortunate 'weather conditions' for that event (i.e., die roll), the chemical release did not affect any of the players in that round. Although, most participants had selected to evacuate to a nearby shelter, their decisions were unimpactful for the given the situation. This *near-miss* Natech scenario surprised players and raised their concern about Natech accidents in subsequent deliberations. It also urged the '*industry manager*', who had enough resources despite the natural hazard impact, to opt for the disclosure of basic chemical information. Knowing which facility handled which type of chemical guided the community discussions to a significant degree. Although none of the players were privy of all the possible chemical accidents or their area of impact, they discussed about how to better protect '*citizens*' near the industrial facilities through community investments on evacuation shelters.

There was no natural hazard in the second round, and therefore deliberations continued in the same direction. The increased resources, however, gave an opportunity to increase

investments in both community and individual preparedness measures; a few wealthy *'citizens'* even reinforced their houses against earthquake. An equally prosperous *'industry manager'* decided to invest in reinforcing accident mitigation measures in one facility—probably nudged by the previous chemical release incident—and expand the other. The third and final round shocked players with an intensity 3 earthquake that incurred heavy damages to industry and houses, and also caused chemical accidents at both facilities. One player went bankrupt, while another one who opted to shelter-in-place was affected by an explosion, so both suffered the corresponding point deductions.

The game concluded with all players having achieved a positive preparedness score; thus, they have 'survived' the natural hazards and Natech accidents that happened in *Egnaria*. In this respect, we did not observe any fatalistic player behaviours involving passing on opportunities to invest in preparedness measures and leaving outcomes only to chance. Players made use of the available preparedness cards individually and—as mentioned earlier—further tried to coordinate their efforts at a community level. In the end, there was one winner based on the total points, with the differences between the top two contenders being mainly how many times they participated in community preparedness drills throughout the game as they had both invested in house reinforcement against earthquake. The player who went bankrupt and the player who was exposed to a chemical release were in the last places.

Finally, it should be noted that confidence votes each time were in favour of the players that acted as *'industry manager'* and *'community leader'*, and so the game session did not include any change in roles. This showed that, despite the initial scepticism, an overall consensus emerged through the deliberations concerning the strategies employed by the two players in question. Additionally, the *'industry manager'* did not end up investing in the second level of Natech risk communication, but they were also not pressured by the community to do so. Although the *'community leader'* contemplated pressuring the industry via special taxation during the first investment deliberation phase, they decided to openly discuss the subject of chemical information disclosure instead. Both players seemed content with the discussions and formed a collaborative relationship as the game progressed. The corresponding Natech risk assessment maps were thus presented by the game master at the end of the session to stimulate the discussion.

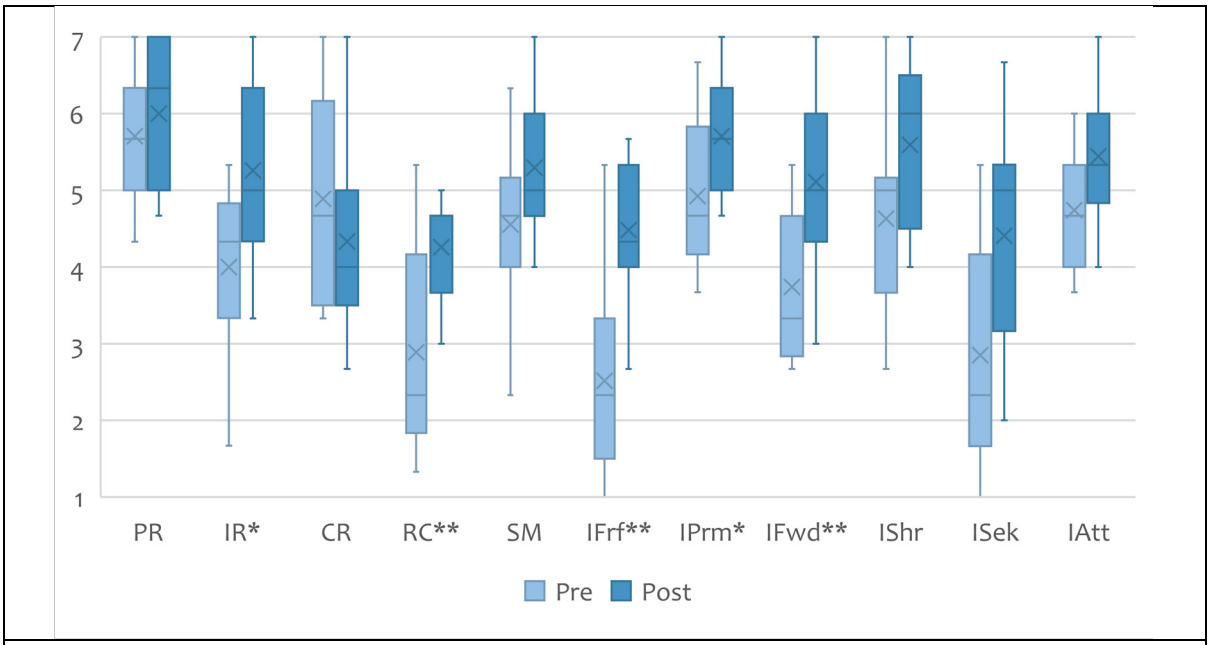
5.5.2 Communicative Behaviour

The results from the pre- and post-game surveys about the players' communicative behaviour concerning Natech accident risk are consolidated in Figure 5.5-1 below. As evidenced in the boxplot, most of the STOPS variables' mean scores seem to have shifted upwards after the workshop. With the exception of perceived obstacles that limit one's ability to resolve the

problematic situation (CR), which seemingly were reduced after playing the game, all other mean scores were increased. It is noteworthy that although many aspects originally measured considerably high in the pre-game—thus indicating a rather initially sensitised audience—indeed, situational perceptions and communicative behaviour alike seem to have been raised through *EGNARIA*. In more detail, the perceived severity of being exposed to Natech accident risk (PR) was slightly increased, but perceived personal connection with it (IR) and the available ideas for solution (RC) saw a considerable rise in their mean scores.

Similarly, players seemed more motivated to communicate about Natech accident risk (SM) after playing the game. In fact, they commented during the debriefing that the game motivated them to learn more and communicate their new-found knowledge about Natech accident risk. They felt that raising awareness in real life about this largely unnoticed hazard is an important step towards coordinating efforts and collectively managing Natech risk as a community. Additionally, participants stated their interest in collecting more information and understanding better the actual chemical accident risk situation where they live, acknowledging the usefulness of risk assessment maps presenting chemical accident scenarios similar to the ones used in *EGNARIA* as effective representations.

Figure 5.5-1 Changes in Communicative Behaviour Pre- and Post-Game



*** Difference is significant at the.01 level (2-tailed).*
** Difference is significant at the.05 level (2-tailed).*

Source: Original work

This trend was also reflected on their intended communicative actions, that exhibited upward shifts in every aspect. In detail, respondents expressed their intent to search for more

information (seeking and attending), become more selective (forefending and permitting) and transmit (forwarding and sharing) more actively information pertaining to Natech accident risks. Moreover, a paired samples *t*-test indicated that the differences in perceived personal involvement (IR), available solutions (RC) and information forefending (IFrf), permitting (IPrm) and forwarding (IFwd) were statistically different, indicating a considerable increase for these aspects.

5.5.3 Natech Risk Awareness

As mentioned multiple times during the discussion session, the majority of participants were unfamiliar with the topic of Natech accidents[18], while a few individuals had never considered such scenarios in the past. Chemical accidents were not perceived as potential threats during the house-allocation stage at the start of the game, and thus players generally ignored them. When asked by the game master during the game setup whether they had sufficient information to decide on their house location, only one participant inquired whether to expect that industrial facilities will be in general safe or not. However, judging from the group discussion afterwards, participants had not previously considered conjoint natural hazard and chemical accident scenarios and the specific challenges they entail. Naturally, this influenced to a great extent the impact the game had on the players' Natech risk awareness.

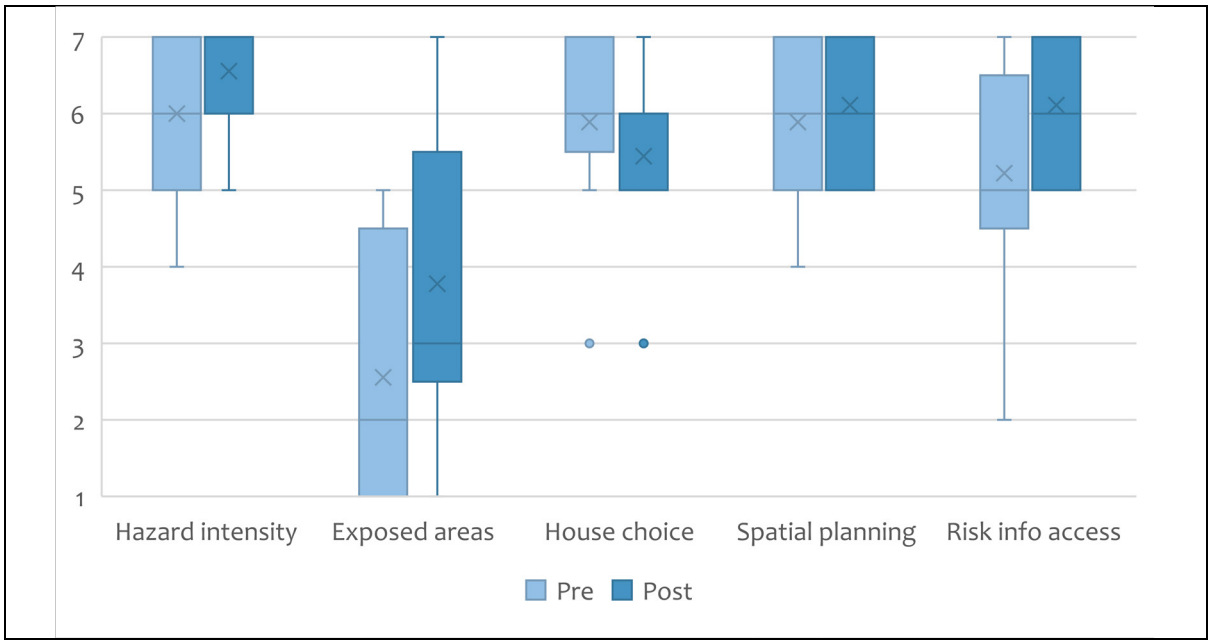
Indeed, the first round proved to be an introduction to the concept/possibility of Natech accidents for many of the players. Although, most participants had been exposed to natural hazards in the past, they highlighted in the discussion that they had not seriously considered the threat from such chemical accidents, and that *EGNARIA* '*opened their eyes*' to Natech accidents in this respect. Despite the fact that they recognised reference examples such as the Fukushima nuclear disaster in retrospect, they were unfamiliar with the idea of Natech accidents.

Moreover, participants noted that the game had a profound impact on their spatial awareness considering Natech risks, as they realised through the game that location is a crucial factor in determining the consequences from such events. Apart from location, players also noted that the through the scenarios they faced during the game, they realised that Natech risk depends on numerous elements, such as the natural hazard intensity, the weather conditions and the mitigation measures in place. Furthermore, it made them think about other types of potential chemical hazard scenarios, beyond the flammable and toxic ones that were featured in the game. Finally, players mentioned that *EGNARIA* helped them understand that the impact of Natech events

[18] Of course, the discussion did not revolve around their familiarity with the technical terminology *per se,* but their level of awareness about chemical accidents triggered by natural hazards.

on the local community can be severe, affecting the population's health but also incurring huge economic losses.

Figure 5.5-2 Changes in Natech Risk Awareness Pre- and Post-Game



Source: Original work

Furthermore, the role-playing aspect of the game, nudged some players to imagine the situation from a different perspective. Particularly, the *'community leader'* and the *'industry manager'* through the course of the game reflected on their decisions and subsequent consequences their actions entailed for the whole *Egnaria* community with respect to Natech risk management and chemical information disclosure. As noted during the post-game discussion, this helped them realise the significant role and responsibility such stakeholders have for DRM, especially considering industrial accidents involving hazardous chemical releases.

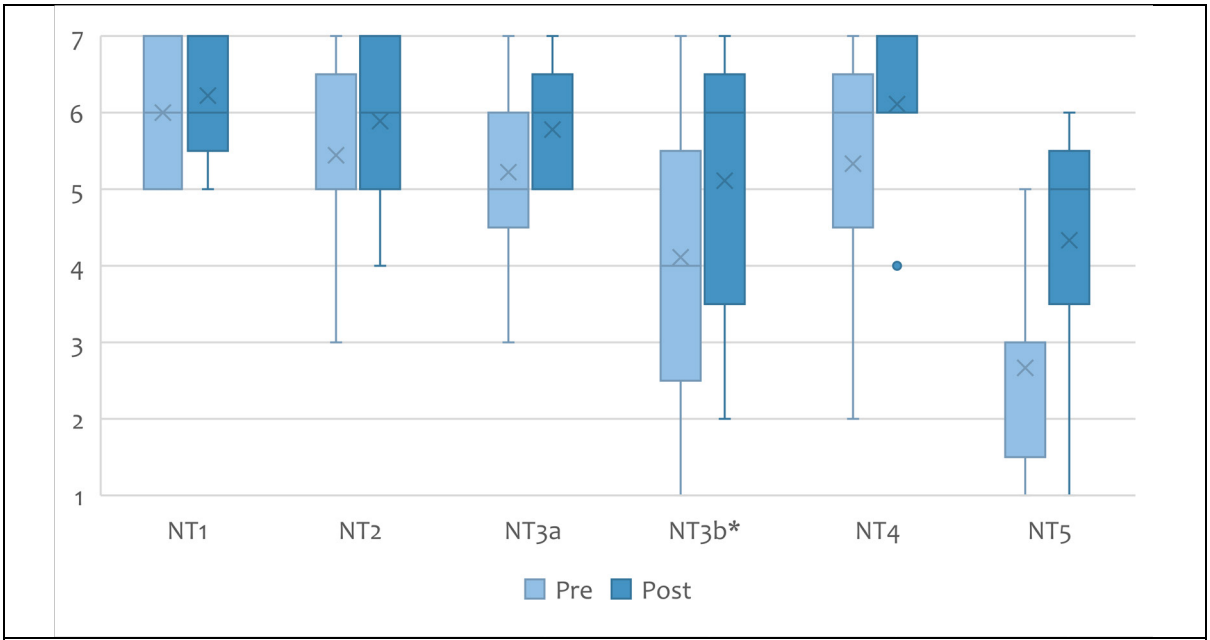
The above points were reflected in the survey results (see Figure 5.5-2). After playing the game, players became more familiar with the relationship between natural hazard intensity and the associate consequences. A considerable change was observed in terms of the perceived spatial distribution of Natech risk, as players seem to have realised that not all areas can be potentially exposed to the same hazards. Nonetheless, post-game results were characterised by high variance. Interestingly, avoiding hazards was a perceived as an important factor when choosing a house initially that slightly decreased afterwards. Perhaps this is related to the fact that players were pre-dispositioned to consider hazards, because they were invited to play a disaster-related game. After playing the game, they noticed that avoiding hazards altogether seems more difficult than originally thought, because of the lack of risk information. In terms of how spatial planning and resource allocation matter for DRR, participants had already acknowledged its significance even

before the game, and so almost no change was observed. However, it is noteworthy that scores were consistently very high across all responses. Considering whether available chemical risk information exerts substantial influence on residents' preparedness actions, opinions were highly varied in the pre-game test. The post-game evaluation revealed a clustering of high scores and thus a general consensus in this regard. Finally, we should underscore the fact that the paired samples t-test showed no significant changes in any of these aspects.

5.5.4 Natech Risk Perception

Changes in Natech risk perception were moderate (see Figure 5.5-3). Measurement scores for the perceived severity (NT1) and general concern about Natech accidents (NT2) were originally high and remained so. Perceived likelihood for a Natech event in around Osaka Bay (NT3a) exhibited a slight increase from its initial state. An important difference was observed, however, in the perceived likelihood of a Natech accident in the participant's everyday environment (NT3b), as participants became apparently more concerned about their immediate surroundings. The perceived exposure of citizens to a Natech accident (NT4) also showed a notable rise in its mean score after the game. Finally, a noteworthy increase occurred in the mean score for perceived self-efficacy for staying safe in case of a Natech accident (NT5). However, a paired samples t-test revealed that only the difference in NT3b was statistically significant.

Figure 5.5-3 Changes in Natech Risk Perception Pre- and Post-Game



** Difference is significant at the.05 level (2-tailed).*

Source: Original work

Similar to the notes about Natech risk awareness above, participants commented that they had not seriously considered Natech accidents as a threat that would impact their lives. Through

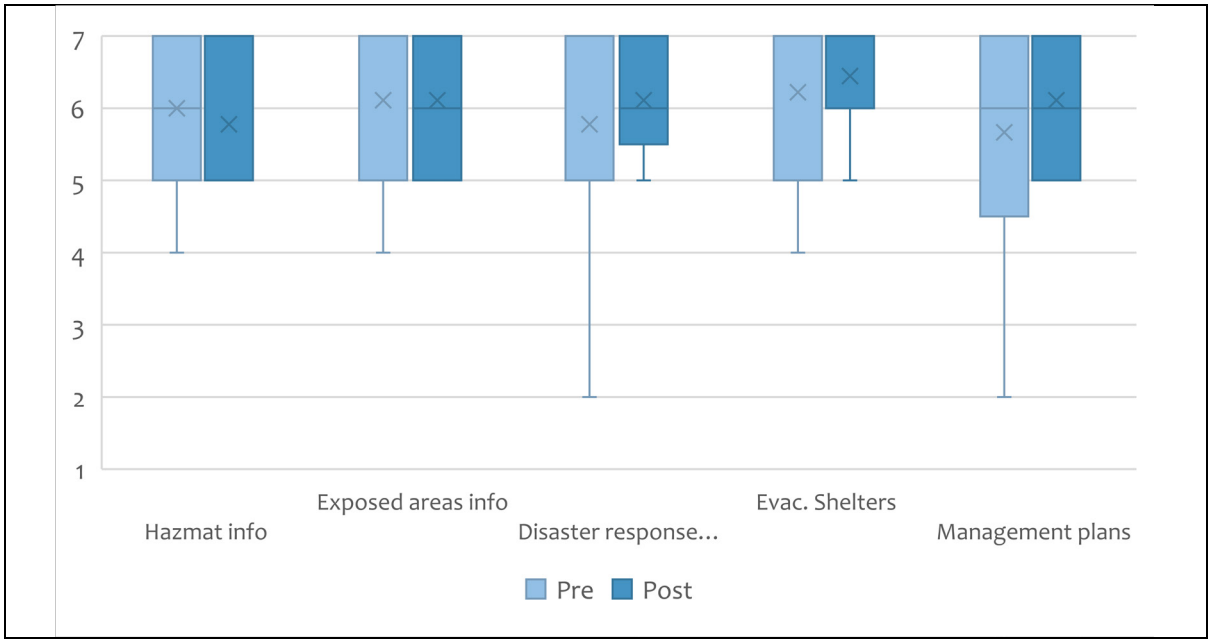
EGNARIA they realised that such accidents can potentially have an enormous area of effect and severe consequences on public health and the local economy. Even though the appreciated that there is a lot of uncertainty involved in the estimation of occurrence and consequences of Natech events (simulated via rolling of dice multiple times during the gameplay), participants underscored during the debriefing session that such chemical accident scenarios are no longer 'unimaginable' for them.

5.5.5 Natech Risk Information

Apart from raising Natech risk awareness, another important consideration for *EGNARIA*'s game design was chemical risk information. As observed from the in-game discussions of players and highlighted later by many of them, issues pertaining to chemical risk information disclosure became evident from the beginning of the gameplay and guided discussions. Particularly, the *'industry manager'* noted that they became personally invested in decisions pertaining to chemical risk communication, as they gradually recognised the implications of their strategies for the entirety of *Egnaria 'citizens'*, including themselves. Chemical risk information disclosure was key for the collective decision-making process of deciding the spatial allocation of the limited community resources. Interestingly, one participant noticed the fact that the *'industry manager'* had initially certain information pertaining to the chemicals handled by the facilities that the rest of the *'citizens'* were not made aware of. As the participant underscored in the discussion afterwards, this made them originally sceptical of the *'industry manager's'* investment strategies, but these concerns gradually dissipated through the open discussions during the investment deliberations. This was confirmed by the fact that the *'industry manager'* received community support through their confidence votes in all rounds.

Access to chemical risk Information played an important role in players' discussions and decisions, as they pointed out in the debriefing session afterwards. It provided crucial input to make informed individual choices for their in-game evacuations, but more importantly allowed them to participate in the debate about the community investments in preparedness measures against the chemical hazards. This step-by-step process of obtaining information via their discussions and the *'industry manager's'* basic information disclosure nudged them to contemplate on the real-world situation concerning access to chemical risk information and the deliberation processes involved in managing chemical and Natech risks as a community.

Figure 5.5-4 Changes in Natech Risk Information Priorities Pre- and Post-Game



Source: Original work

In retrospect after the game, participants recognised that they lacked crucial information about the potential chemical accidents at the start when contemplating their house location. One participant noted this deliberate 'deception' from *EGNARIA*'s perspective, but while reflecting on it during the game, they concluded that it was an effective argument used to convey the importance of chemical risk information disclosure. Moreover, the incomplete risk information players had in the beginning of the game resembled for some participants real-world conditions, where chemical accident risk is largely ignored and/or limited to industry and governments. Overall, participants understood through their play that the information disclosure has direct positive effects on community preparedness against Natech accidents, but also potential economic costs for the related industries. Nonetheless, it was evident that information-sharing would be a good strategy for the players.

Our questionnaire included certain questions aimed at capturing any changes in players priorities for Natech risk information disclosure (see Figure 5.5-4). The mean scores describing the subjective value participants ascribed to different sorts of chemical risk-related information were initially quite high. Our results showed that answers became more consistent after the game session, although differences in the mean scores were almost imperceptible. In detail, players evaluated consistently high the importance of disclosing Information about the types of hazardous chemical substances and their adverse health impacts (hazmat info), about areas potentially affected by chemical accidents (exposed areas info), about chemical accident preparedness training (disaster response info), about available evacuation shelters (evacuation shelters), and

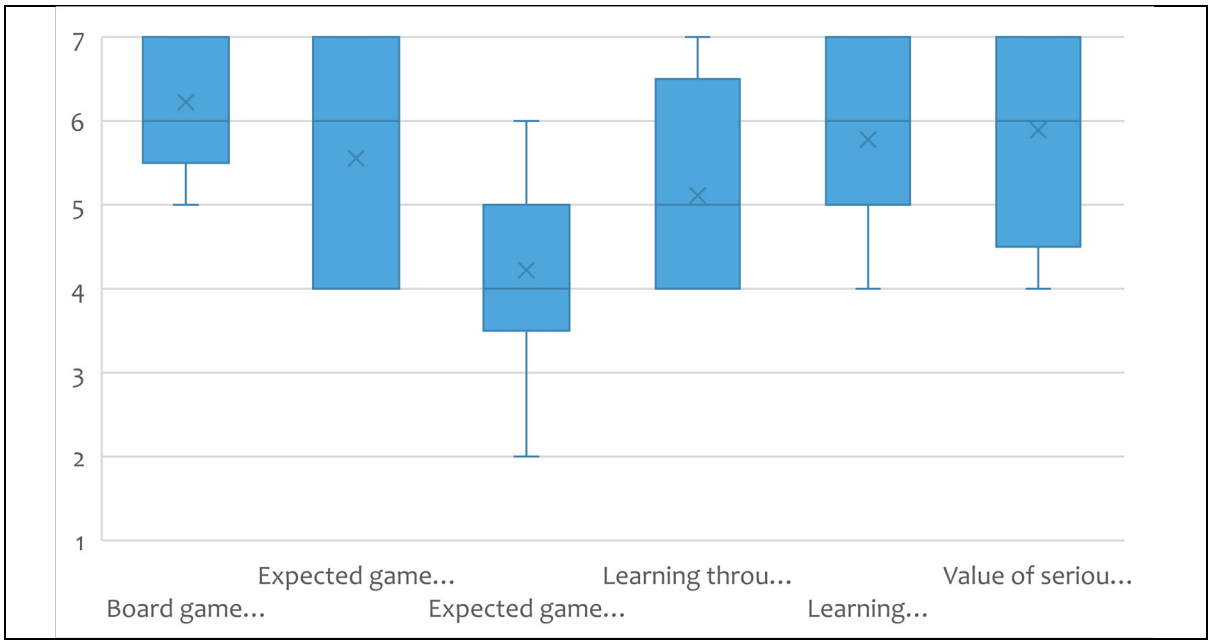
about existing chemical accident preparedness plans from governments and industries (management plans).

5.5.6 Players' Impressions of the Game

5.5.6.1 EGNARIA as a Serious Game

The participants' opinions about the game were mainly gathered from the discussion that took place after the workshop. The general impression of *EGNARIA* was quite positive. First and foremost, participants found the game fun. The mentioned that it was an engaging and pleasant activity overall. They found themselves participating so actively in the discussions during the investment deliberation phases that stricter time-keeping had to be implemented by the game master in order to meet the allotted workshop times. Even though only few participants had been acquainted with each other prior to the workshop, everyone seemed to participate—albeit in various levels—to the discussions, while through the voting phase, all players had the opportunity to express their opinion. Of course, the group dynamics played a crucial role in establishing and fostering a favourable collaboration climate, as also pointed out by some players after the game session.

Figure 5.5-5 Players' Expectations Pre-Game



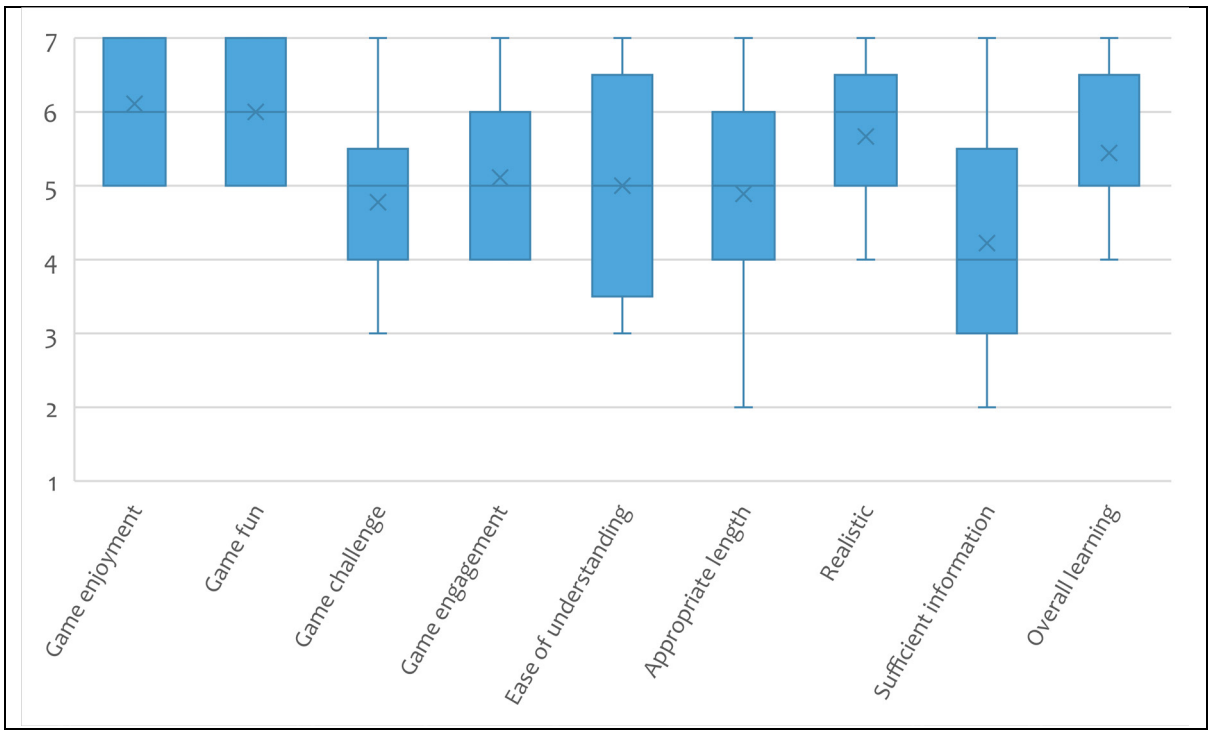
Source: Original work

One of the main challenges encountered during their gameplay was understanding all the complex interactions involved in the game mechanics, although opinions diverged on this issue. For example, one participant noted that they wished they had played more 'warm-up' rounds before a hazard struck in order to experiment and discover advantageous strategies that would

give them a competitive edge. On the other side of the spectrum, other participants noted that—although perplexed about the intricacies involved in this *EGNARIA*'s mechanics—they felt that they offered a good balance and an interesting representation of the arguably more complex reality. Besides, information disclosure—as they supplementary noted—helped them gain a better understanding as the game progressed.

Our research design incorporated a few questions about the expectations of the participants, in order to be used as a reference for the subsequent evaluation of their engagement with the activity (see Figure 5.5-5). Participants generally had previous experience of playing analog games, and expected to learn through the game. Interestingly, responses fluctuated highly around the midpoint with regard to their expectation of enjoyment from playing games. They were confident in their ability to understand and win the game, and expected to learn much from it. Finally, they mostly regarded educational games as a valuable educational resource.

Figure 5.5-6 ***Players' Impressions Post-Game***



Source: Original work

After completing the game session, questions about the impression of the game were more targeted (see Figure 5.5-6). Confirming the remarks from the debriefing session, players judged their experience as quite fun and enjoyable, and mostly engaging. Opinions were varied in terms of the perceived level of game challenge that received a moderate score overall perhaps due to the randomness involved in the game mechanics, as discussed by a few participants. Likewise, opinions diverged in consideration of the ease of understanding of the game; as explained earlier

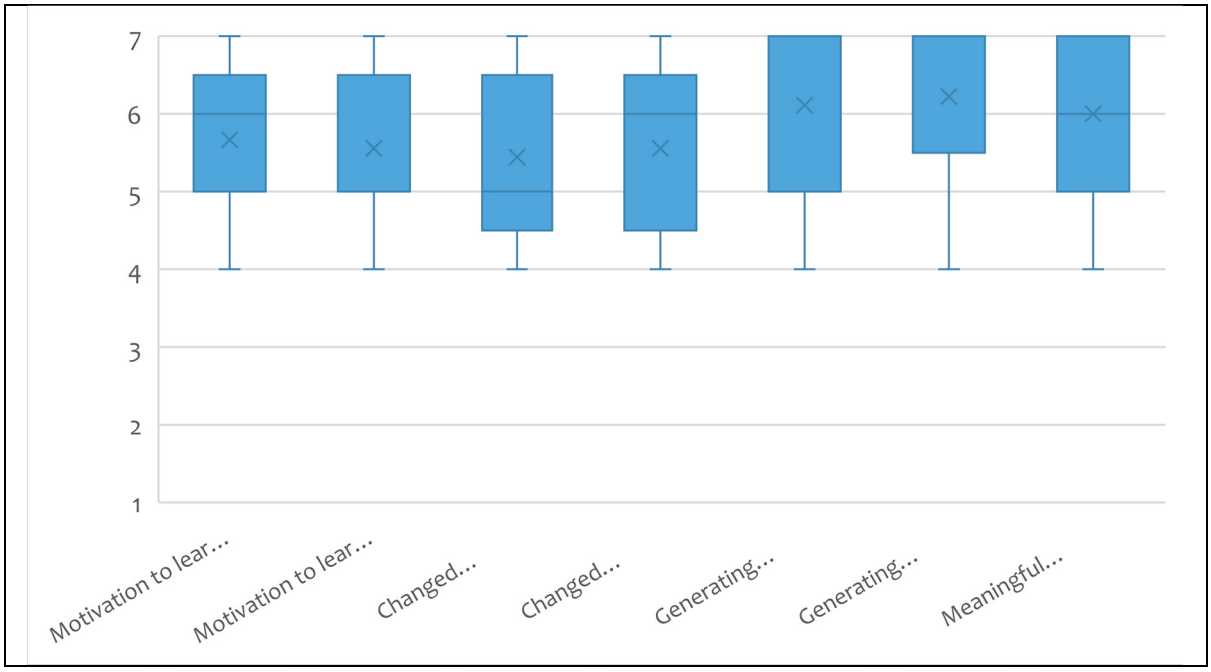
some participants found the simplifications made to be adequate, while others thought it was complex. This point is directly related to the next question, which also received highly varied scores. A few players indeed noted that they had *'just warmed-up'* after the end of the third round, yet the predetermined workshop time had already passed. Moreover, players evaluated the level of realism in the *EGNARIA* satisfactory. The game scored moderately with regards to the information it provided, but with highly varied response scores. As discovered later through the discussion, a few of the players were left with the impression that they were still lacking chemical accident preparedness instructions. Nonetheless, *EGNARIA* was highly appreciated as an educational experience that had taught them many new ideas by the end of the session.

5.5.6.2 *EGNARIA as Tool for Natech Risk Communication*

The last aspect taken into consideration for the evaluation of EGNARIA was the participants' impressions of the game as a tool for Natech risk communication. Even though participants noted their limited knowledge and experience in the field of DRM, they offered their views. One common point of agreement was the value for raising community awareness. Natech accidents pose a threat that remains largely unnoticed by the local communities, and *EGNARIA* seemed to participants as a promising tool to make an introductory discussion. Moreover, the role-playing element was highly appreciated as it offered an opportunity to consider Natech risk management from various perspectives. One participant noted that this element actually served as a decent 'substitute' for not having actual stakeholder representatives when conducting this kind of community workshops. Additionally, the incorporation of randomness through the multiple dice rolls, was underscored by one participant as a meaningful game element that nudged them to think about the uncertainties involved in the disaster risk assessment process.

Another important point was the players' collective realisation about the importance of chemical risk information. According to one participant, they felt that they learned a lot about information-sharing, and that engaging collaboratively in DRM holds significant merits in effectively reducing such kind of disaster risks. Although there are decisions which are beyond the control of everyday citizens but affect them directly, for many participants *EGNARIA* demonstrated that through transparency and public deliberation community preparedness against Natech accident risk can be substantially improved, protecting human lives and properties. Finally, participants agreed that *EGNARIA*, while it may offer little to the DRM-related deliberation processes amongst professionals and experts, indeed can be a valuable educational tool for lay audiences; apart from introducing Natech accidents, it explores elements of risk information sharing, community vulnerabilities and even ethics and activism.

Figure 5.5-7 Players' Evaluations of EGNARIA as a Natech Risk Communication Tool



Source: Original work

Finally, we asked participants to submit their assessments about *EGNARIA* as a means for chemical and Natech risk communication (see Figure 5.5-7). At first glance, it becomes apparent that the serious game received very high scores across all categories; it is noteworthy that none of the participants' scores fell below the midpoint of the scale. In detail, after playing *EGNARIA* participants felt generally quite motivated to learn more about chemical and Natech accident risks. Furthermore, they identified a change in their perceptions vis-à-vis both chemical and Natech accidents. They, also, recognised *EGNARIA*'s potential to generate a discussion around the subject of disaster preparedness against chemical and Natech accidents. Overall, they acknowledged the game as a meaningful educational tool with scores that reflected their comments.

5.6 Discussion

5.6.1 Learning Outcomes

First and foremost, as evidenced through the survey results and the group discussion, *EGNARIA* exposed the majority of players to a completely new concept for them: Natech accidents. Despite the limitations imposed by our attempt to provide a simplified introduction to an inherently complex issue (Shimizu & Clark, 2019; Eisner, 2014) the game seems to have achieved in creating an immersive scenario-based environment that facilitates *experiential learning* (Kolb, 2014). Similar to other round-based, DRM-related serious games (de Ruiter, Couasnon, & Ward, 2021; Mossoux et al., 2016; Cremers et al., 2015), *EGNARIA*'s game design encourages learning-by-doing and invites players to experiment and develop dynamically their strategies taking into

consideration others' decisions and the in-game events. Furthermore, as players mentioned, *EGNARIA* enhanced their spatial awareness concerning chemical accident risks and nudged them to reflect about the real-world conditions, agreeing with previous research findings (M.Nazry & Romano, 2017; Cremers et al., 2015). Overall, our findings about the usefulness of serious games in a DRM setting align with previous studies (see Solinska-Nowak et al., 2018) and confirm their effectiveness in explaining complex technical concepts to broader audiences (Yamaguchi et al., 2018).

Moreover, the use of an abstract setting for the game seems to have not distracted players so much as to become detrimental to the reflective process, thus allowing them to juxtapose their personal experiences and understandings. These findings agree with other DRM-related serious games that utilised a similar approach (de Ruiter, Couasnon, & Ward, 2021; Mossoux et al., 2016; Cremers et al., 2015). As Solinska-Nowak et al. (2018) noted, learning in DRM-related, role-playing games is dependent on the level of immersion and active participation of all players. As evidenced by the survey results and commented by players during the debriefing, they became quite absorbed by their roles and tried to strike a balance between pursuing their individual interests and the community's needs during the game. Additionally, the game master was at a position to function as an external discussion moderator during the deliberation phases in the game, allowing them to encourage the active participation of all players. Previous face-to-face DRM-related games with an analogous facilitator role discovered equally successful findings with this method (de Ruiter, Couasnon, & Ward, 2021; Mossoux et al., 2016).

EGNARIA is designed in such a way to be played in several rounds and allow players to gradually grow more accustomed to the idea of Natech accidents, consider appropriate preparedness actions and revaluate their informational needs. Naturally, there is a steep learning curve for *EGNARIA* players, such as community members, that may be unfamiliar with the concept of Natech accidents or are introduced for the first time to the terminology. However, as the first round starts, players are required to make important decisions about house location or resource usage and so confront this challenge early on. Although this was originally noted as a game limitation by the participants, this procedure seemed effective in creating a fertile ground for critical thinking that can eventually help the community members to better understand their environment, the potential hazards they have in their vicinity and the importance of cooperation among all stakeholders. Previous DRM-related serious games that adopted such an approach reached similar conclusions (Mossoux et al., 2016).

5.6.2 EGNARIA as a Game

Overall *EGNARIA* was regarded as an enjoyable and fun activity. Participants would generally recommend it to others. They reported that they had fun, were substantially engaged through the process and were immersed in their roles as '*citizens*', '*community leaders*' and '*industry managers*'. Players seemed sufficiently stimulated through unexpected, random hazard events and their consequences throughout their gameplay with the scenarios they faced, which contributed to their general satisfaction (Mossoux et al., 2016; Pereira, Prada, & Paiva, 2015; Bogost, 2008). At the same time, the round-based format that alternated between collective decision-making, group voting, individual consequence estimation and scenario determination was highly appreciated by the players, as it provided them with a structured, yet dynamic, process that retained their level of engagement throughout. The phases of investment deliberation provided excellent opportunities for participants to reflect on the DRM practices and contribute from their perspective to the debate, as with other discussion-based DRM-related games (see e.g., Mossoux et al., 2016; Cremers et al., 2015; Yamori, 2008).

In addition, participants had high expectations for *EGNARIA* before the workshop, and expected to perform well and learn through playing. Our results demonstrated that these expectations were mostly met. The ease of understanding, level of engagement and challenge of the game were all evaluated as above average, while in terms of the educational aspect, *EGNARIA* was highly appreciated for its subject, the degree of freedom in player choices and level of realism. However, It should be noted that participants were positively pre-dispositioned towards learning through games originally; approaching the activity with a mindset open to acquiring new ideas and information can certainly enhance the effectiveness of the educational tool (Kolb, 2014). Thus, the game may have limited impact if met with scepticism and disinterest from participants at a multi-stakeholder or community workshop in real life. In this vein, it is important for risk communicators to carefully consider the audience prior to the application of *EGNARIA* or other similar serious game, and rather incorporate it in a comprehensive risk communication strategy.

The gameplay itself was noted as moderately intuitive for participants. However, as they discovered more about the systemic linkages involved in Natech risk management, their perspectives changed for the better. In any case, this is a known issue with DRM-related serious games that are intended for a broader audience (Taillandier & Adam, 2018). More importantly, *EGNARIA* presents significant challenge from a workshop facilitation perspective. It is arguably very complex by design and requires an in-depth comprehension of its game mechanics by the game master in order to run smoothly. Additional assistants are also recommended. Nonetheless, this is another issue that is not unique to this approach (see e.g., Mossoux et al., 2016). Finally, the

deliberation process is highly dependent on the participants personalities and group dynamics. Our workshop participants did not have any conflicting interests, but this might not be the case if this method is employed for a multi-stakeholder community workshop in which representatives of governments, businesses and everyday citizens are invited to participate. Therefore, DRM practitioners need to pay due attention in establishing a calm and respectful discussion environment (Mossoux et al., 2016; Clerveaux, Spence, & Katada, 2010; Clerveaux & Spence, 2009).

5.6.3 EGNARIA as a Tool for Natech Risk Communication

Many DRM-related serious games target younger audiences and have been designed to raise awareness about a single or a group of hazards and share information about disaster preparedness measures and protective actions in a simplified way (see e.g., Tsai et al., 2020; Pereira, Prada, & Paiva, 2015; Clerveaux, Spence, & Katada, 2010). On the side of the spectrum, there is a growing number of DRM-related serious games for more mature audiences, aimed at experimenting with various DRR strategies and stakeholder interactions or exploring multiple hazards and systemic risks (see e.g., de Ruiter, Couasnon, & Ward, 2021; Mossoux et al., 2016; Cremers et al., 2015). *EGNARIA* falls in the latter category of such serious games, and takes on the challenge of raising awareness about Natech accidents and generating a discussion among stakeholders about Natech risk communication and management strategies.

In contrast to other multi-hazard serious games in the past, *EGNARIA* is the first game—to the best of our knowledge—developed specifically to explore and communicate the complexities of Natech scenarios, i.e., chemical accidents caused by natural hazards. The game features different types and intensities of triggering natural hazards with context-dependent consequences, and multiple chemical release scenarios. Furthermore, it provides players with a high degree of freedom through diverse preparedness actions at both an individual and community level with various synergies among them. Finally, the game places great emphasis on collaborative decision-making for DRM and access to chemical risk information incorporating them as key gameplay mechanics.

The promising results of our trial application can be considered as proof of concept for this novel serious gaming approach for Natech risk communication. Many players were introduced to the concept of Natech accidents for the first time, and according to their comments, gained an overall understanding of their potential consequences and how they can collectively manage this type of risk. With respect to the narrative of STOPS (Kim & Grunig, 2011), players became more concerned about Natech accident risks as problems that can affect them personally and need to be resolved through proactive communication, particularly through seeking information and forwarding it to others. Cremers et al. (2015) observed a similar activeness in players' intended

communication attitude after the trial of their serious game, noting an increased motivation to search for information and discuss with others. Moreover, participants seem to have obtained more ideas about how to address this issue after playing *EGNARIA*, which probably accounts for the increased activeness in information selection behaviour reflected through our survey results. Workshop participants seemed to have a better grasp of the topic after the game session, which led to 'stricter' selection criteria for information about Natech accident risks that—according to their individual understanding—contribute to a solution and are worth searching for and transmitting to others.

Considering our findings about Natech risk perception, it was no surprise that the general concern about the perceived severity and likelihood of such technological accidents was initially high. Indeed, Natech accidents are typical high-impact/low probability technological risks (Masys et al., 2014), and so people usually perceive them as highly unfamiliar and dreadful risks with long-term consequences (Slovic & Weber, 2002). However, players noticed a change in their perceptions about chemical and Natech accident risk after the game, particularly with respect to their personal exposure. Likewise, the spatial variation of exposure and consequences of Natech accidents was a recurring point during the discussion, and also exhibited the largest change in terms of awareness based on the survey results. Apparently, the scenarios players faced in *EGNARIA* effectively demonstrated that large-scale chemical accidents caused by natural hazards can potentially have severe consequences on human health and affect a considerable part of the local community. For example, a toxic cloud in the *EGNARIA*, conditional to the weather parameters, could affect areas that would not be impacted by a tsunami of moderate intensity. This is also a probable explanation for the observed discrepancy in players' perceived likelihood of Natech accidents nearby locations where they live/work, and additionally the perceived Natech accident exposure in our results.

Interestingly, players demonstrated a noteworthy increase in terms of perceived self-efficacy in staying safe in case of a Natech accident. While *EGNARIA* includes a rudimentary mechanic of emergency response (i.e., players decide between sheltering-in-place or evacuating at a shelter), the game does not provide factual information or detailed descriptions of emergency actions. Similar to other DRM-serious games (Cremers et al., 2015), *EGNARIA* intends to stimulate discussion and knowledge exchange among players regarding appropriate preparedness measures for Natech accidents as well as potential implementation challenges (e.g., resource allocation, consensus-building). In this respect, our approach aims at increasing awareness about potential DRR strategies, which would in turn motivate and guide interested individuals to seek additional information about the potential chemical risk, preparedness measures and response

actions. Besides, appropriate response actions to chemical accidents are highly context-specific and depend on the actual hazardous substance and the release conditions. Incorporating such elements would conflict with the abstract and relatively simplified game design of *EGNARIA* that accommodates non-expert audiences, among others. Nonetheless, raising awareness about general concepts such as community preparedness drills, sheltering-in-place or protective equipment against harmful chemicals, can enhance substantially disaster preparedness by familiarising and mentally training individuals to understand and respond appropriately to emergency warnings in relevant scenarios (Sufri et al., 2020).

Access to chemical risk information was literally a game-changer for players. As they commented, players experienced first-hand what significant implications information disclosure had on their individual preparedness choices, how it shaped public deliberations and stakeholder interactions, and further how it facilitated a more efficient and fair spatial distribution of resources. The core message of *EGNARIA* is that disaster risk communication offers a way to empower community members at risk to make informed decisions in order to protect themselves and their properties (Bradley, McFarland, & Clarke, 2014). We would argue that the feedback we obtained reflects the intended purpose of *EGNARIA*, and provides evidence for the effective communication of this message to non-experts in DRM. On the other hand, participants judged all types of Natech risk information as equally very important before the game with only a slight increase afterwards. Considering our quite educated sample, however, it was no surprise that participants deemed access to information about chemical substances, exposed areas, preparedness training, evacuation shelters and other emergency management plans as critical for their safety. Even so, we would argue that *EGNARIA* managed to persuade a couple of players to upgrade their perceived level of importance for such chemical risk information during their playthrough.

Perhaps more importantly, players noted that *EGNARIA* piqued their interest to learn more about and understand better both chemical and Natech accident risks. Past DRM-related serious games aimed at raising risk awareness (Mossoux et al., 2016; Cremers et al., 2015) also reported analogous findings. Furthermore, *EGNARIA* was received as meaningful educational tool of particular value in educating communities. Participants noted the game's potential to generate a discussion among stakeholders about preparedness strategies against chemical and Natech accidents. The immersive scenarios allowed participants to familiarise with the idea of Natech accidents, explore risk management strategies from the perspectives of community, government and industry, as well as participate in a collaborative decision-making process about DRM. In this regard, our results indicate that *EGNARIA* succeeded in creating an imaginary world where players

could simulate a *process* of *co-management* and *co-production of knowledge* among all community stakeholders (Shimizu & Clark, 2019).

EGNARIA aspires to create a '*communicative space*' (Okada, 2021), which will generate and encourage a discussion around the subject of Natech risk management. In this respect, our findings demonstrated that EGNARIA can raise players' awareness about Natech accidents and excite their interest for chemical risk information, which seems to motivate them to communicate proactively about DRR measures. Considering the above, we would argue that *EGNARIA* can be used as a way of cultivating such a '*communicative space*' (Okada, 2021) among community stakeholders. Therefore, it could serve as a '*boundary object*' (Chabay, 2018) through which players are invited to discover by themselves the importance of community participation and chemical risk information disclosure, while offering them a new perspective to understand the environment they live in and the potential risks they are subject to. Risk communicators can implement *EGNARIA* in a multi-stakeholder workshop in order to introduce a public debate about Natech risk management and engage a relationship-building process.

After all, *EGNARIA* is a *persuasive game* (Jacobs, 2018; Bogost, 2007) aimed at highlighting the significance of chemical risk information disclosure and generate a discussion about community participation in Natech risk management. In this respect, we discovered that our intended message concerning the value of chemical risk information disclosure came across. Players seem to have been confronted with the issue of chemical risk information deficiency multiple times throughout their gameplay, both individually and as a community, even contemplating ethical implications at times. Therefore, we would argue that *EGNARIA* seems to follow the '*risk dialogue*' paradigm (Wardman, 2008) with regard to Natech risk communication. According to our findings from the discussion and the survey, the game seems to improve the understanding of all players by raising awareness about Natech accident risk, community vulnerabilities and potential preparedness measures in order to facilitate symmetrical risk communication (Grunig, 2018; Ni et al., 2015) and risk-informed decision-making (i.e., *normative*) (Wardman, 2008; Fiorino, 1990). Additionally, *EGNARIA* invites participants to contribute to a public debate concerning Natech accident risk and collaboratively decide about the management strategies (i.e., *substantive*) (Wardman, 2008; Yamori, 2008; Fischhoff, 2005).

5.6.4 Limitations and Further Development

Regarding the limitations of the workshop, the context in which *EGNARIA* was first applied to, the following points should be mentioned. First, due to logistic limitations, the participants were not actual community members or stakeholder representatives. Additionally, their educational level was considerably above average—since all of them came from a university

environment—and the mean age was low compared to the Japanese reality. Considering that *EGNARIA* is intended to function as a Natech risk communication tool for communities, this study recognises sampling bias and under-coverage error as caveats concerning the generalisability of our results (Waterfield, 2018). Similar to other DRM-related game trials (Cremers et al., 2015), we speculate that different target groups will probably provide different survey results, and in this regard further research is needed to assess the impact of this serious game in various contexts. In fact, we would argue that *EGNARIA* can have an amplified impact if played with local community members.

Another limitation related to our sample is that the number of participants did not allow for robust statistical analysis of our questionnaire survey data. However, a group of nine (9) individuals is within the recommended number range of participants for a focus group discussion (typically between six and twelve), allowing for a plurality of opinions and in-depth analysis of arguments (Bernard, 2017; Krueger & Casey, 2014). At the cost of statistical robustness, this approach facilitated our debriefing discussion session after the game during which we were able to collect valuable qualitative data for *EGNARIA*'s assessment. In any case, future trials of *EGNARIA* are invited to use the developed questionnaires to systematically gather more data for its evaluation, and perhaps even conduct comparisons across various target groups.

Moreover, due to COVID-19 restrictions the participants had to respect social distancing measures (e.g., wear masks) and engage in a more confined manner. Although this is not expected to have impacted the overall impressions of players about the EGNARIA, it may have somewhat constrained their interactions during the investment deliberation phases. Based on what we observed, the atmosphere was friendly and relaxed in general, but we cannot help but wonder whether discussions would have been more animated under different conditions.

Another issue is related to the assessment of *EGNARIA*'s impact in the long-term. Following a research design of similar past studies (see e.g., de Ruiter, Couasnon, & Ward, 2021; Mossoux et al., 2016; Cremers et al., 2015), at this stage we have conducted a quasi-experiment with a pre- and post-game survey just a few hours before and after the actual game session. It can be argued that the expressed players' motivation to learn more and communicate about Natech accidents may fade over time. Actually, Nakano et al. (2020) have highlighted this rather common shortcoming of educational activities and have concluded that comprehensive education plan and continuous efforts are needed to maintain individual's proactive attitudes toward disaster education over the long-term. Indeed, more research is required on the evaluation of serious games' impact over long periods of time (Solinska-Nowak et al., 2018). Follow-up studies may utilise the developed survey

instruments to assess players' perceptions and communicative behaviour over longer intervals in the future.

As far as the game itself is concerned, a major challenge of *EGNARIA* was achieving a balance between simplification and realism. As mentioned earlier, certain 'interpretations' of real-world Natech accident mechanisms as well as DRR measures had to be presented in a more comprehensible and generalised way. For instance, we have only included three (3) hazard intensity levels, while we assume only predetermined chemical release scenarios and we do not describe in particular what seismic retrofitting would actually entail. Such elements are meant to stimulate discussion and create an 'appetite' to discover more information, rather than convey immediately applicable information. However, this issue is inevitable when it comes to DRM-related serious games that target broader audiences (Solinska-Nowak et al., 2018; Taillandier & Adam, 2018; Mossoux et al., 2016). Naturally, approaches that avoid technical terms or complex systemic linkages have limited value for DRM experts. In our case, while players noted certain simplified mechanisms, they still appreciated hints of realism in the game, such as the randomness (via dice rolling) involved in income and chemical accident scenario determination. Therefore, based on the participants' evaluations and the purpose of the serious game, we would argue that *EGNARIA* performed satisfactorily in this aspect.

Moreover, *EGNARIA* is an intricate serious game and needs a facilitator who is quite familiar with the game mechanics in order to run the workshop and guide the discussion afterwards. Additionally, due to the uniqueness of the DRM topic, the organisers need to be knowledgeable about Natech accidents in order to support players during their playthrough and answer their initial questions. So far, the *EGNARIA* has been implemented only by the original developers, and thus special training may be required for future researchers and/or practitioners interested in this workshop method. In order to assist in this regard, an *EGNARIA* instruction manual has been created for future use.

On top of that, the activity is quite lengthy overall. *EGNARIA* is not suitable for workshops with an overall duration of less than three (3) hours, especially considering that the set-up and 'warm-up' rounds require a detailed explanation of rules to participants and therefore progress quite slowly. A game session is recommended to have at least three (3) full rounds so that players can experience various Natech accident scenarios with each iteration of the DRM cycle. From our development trials, some participants suggested that having some extra time to play more rounds might help them understand the game and its systems even better. Indeed, following the recommendation of Mossoux et al. (2016), a practicable strategy for risk communicators would be to organise multiple workshops and focus on different aspects of the game each time. For example,

at the first workshop, one would start by playing *EGNARIA* and then discussing about the Natech accident mechanisms; in the next workshop, the post-game discussion could concentrate on chemical information disclosure; and at the following one, on community DRR and preparedness measures.

EGNARIA's fruitful first trial application provided inspiration for potential improvements of the game in the future. The original version of the game takes place the imaginary city of *Egnaria* and was developed considering an earthquake-prone and tsunami-prone coastal region, and with specific chemical substances. This abstract approach has arguably its merits when it comes to the implementation of *EGNARIA* with participants from diverse backgrounds. However, the main gameplay mechanics could be easily adapted to accommodate the needs of particular target groups. Going forward, *EGNARIA*'s mechanics can be updated to include more and/or different types of chemicals or triggering natural hazards, so that the participants will be introduced to various chemical scenarios that may be directly related to their reality. For example, future versions of *EGNARIA* can be created with reference to other types of environments, including geographic elements such as mountains or rivers that correspondingly introduce landslide and flood hazards, or even simulate the geographic and hazard profile of a specific, real-world region for the in-game scenarios. Moreover, the current version includes only generic categories of game roles. With a cautionary note against creating an overwhelmingly complex game, future versions may explore the possibility of adding fictitious personality profiles or everyday scenarios for the '*citizens*' of *Egnaria*. For instance, players could follow additionally unique instructions based on 'mission cards' or 'character sheets' that would immerse them in more realistic situations within each round and would restrict their available emergency actions. Additionally, *EGNARIA*'s materials can be translated from the original English version in other languages with respect to specific terminology in order to enhance the game's accessibility to broader audiences and contribute further to citizen accessibility and translation of science.

Finally, even though players were pleasantly surprised by the educational potential of such a fun activity, as they mentioned, we cannot claim that *EGNARIA* functions as a standalone, all-encompassing teaching tool that could substitute disaster education for Natech accidents. Instead, acknowledging the limitations of DRM-related serious games (see Solinska-Nowak et al., 2018) in consideration of risk communication, this approach is intended to complement broader Natech risk awareness and communication strategies and frame an open dialogue that fosters a co-learning process for communities (Shimizu & Clark, 2019; Okada, 2018); it is designed to introduce the public risk debate around Natech accidents and provide stimulus for participatory DRM and community engagement. Thus, supplementary material with more detailed information about the

characteristics of Natech accidents, hazard exposure and associated vulnerabilities can be developed in the future that would help participants better understand Natech accident and contribute proactively to the public risk debate.

5.7 Conclusions

This study proposed and developed *EGNARIA: an Educational Game for Natech Risk Awareness*. It is a novel, educational, role-playing board game considering earthquake and tsunami scenarios that might cause subsequent chemical accidents. In this serious game, players try to survive by taking disaster preparedness actions and responding correspondingly to the natural and chemical hazards they face. The game has been designed to raise community awareness about Natech, and generate a discussion among stakeholders about risk management strategies, chemical information disclosure and risk-informed decision-making concerning Natech accidents. Additionally, this study proposed the use of STOPS as an interpretative framework that could be incorporated in evaluation methods for DRM-related serious games and could assist with measuring changes in players' behaviour with regard to risk communication about Natech accidents.

For our study, in order to assess *EGNARIA*'s impact on participants' perceptions and communication behaviour regarding Natech accident risk, a quasi-experimental design was employed with a questionnaire survey before and after the trial application with university affiliates. The preliminary findings from the game trial suggest an overall positive reception from participants as an engaging, educational tool to introduce communities to Natech accident risk and discuss about its management. Participants noted that the game raised their awareness about Natech accidents, highlighted the importance of community participation and chemical information disclosure, and positively affected their intentions to actively search for and share information about Natech risk. Overall, *EGNARIA* proved to be a fun, informative and stimulating DRM-related serious game.

Concluding, we should reiterate the significance *EGNARIA*, since it is the first serious game—to our knowledge—specifically developed for raising risk awareness about Natech accidents. The trial application of the game provided promising findings about its impact, which serve as proof of concept for further development and implementation of *EGNARIA* as a risk communication tool to support DRR education programmes. By filling a research gap in the emerging field of Natech risk communication, *EGNARIA* aspires to be used as a participatory DRM tool for communities that stimulates the discussion around risk information disclosure and chemical accident preparedness. Future DRM researchers and practitioners are welcome to implement, experiment and expand on this serious game in the future.

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Chapter 6 Conclusions

This research set out to expand our current understanding of Natech risk communication through a cross-national, comparative study on how citizens communicate about Natech risk information disclosure, and also by proposing and developing a serious gaming approach for Natech risk communication and community involvement. More specifically, this study ventured to explore the communicative behaviour and perceived challenges of households in Japan and S. Korea concerning the issue of Natech risk information disclosure. We focused on identifying the determining factors that affect community perceptions and communicative behaviour with respect to chemical and Natech risk information disclosure, and further evaluate any influences from sociocultural dimensions. Moreover, the study designed and tested *EGNARIA*, a novel serious game for Natech risk communication. This educational game offers an experiential, co-learning method to introduce and enhance Natech risk communication and collaborative decision-making among stakeholders, targeted at raising awareness and literacy about Natech accident risk, appropriate preparedness measures, and the importance of risk information disclosure.

As determined from the academic literature (Chapter 2), much emphasis is placed by scholars and practitioners upon effectively addressing public concerns through the creation and enhancement of a cooperation environment between institutions and communities, based on transparency and meaningful communication. While there have been a few notable regulatory frameworks over the years (e.g., see EPCRA or the Seveso Directives), international organisation calls for further advancements concerning chemical risk information disclosure are more relevant than ever. Chemical risk communication gains particular importance in view of right-to-know initiatives that not only enhance community capacity-building to better prepare against chemical accidents, but also empower them to contribute to the public risk debate and proactively participate in risk management. Furthermore, a comparison between the Korean and the Japanese legislation systems revealed a gap of the latter in terms of community right-to-know initiatives for chemical risk information disclosure. Finally, previous research efforts revolved mainly around understanding risk perceptions for technological accidents, and so there is a growing academic interest for further research on individuals' communicative action patterns, especially considering the emerging field of Natech risk communication.

Chapter 3 started by framing the lack of Natech risk information as a cognitive *meta-problem* that stems from the original, underlying Natech accident risk. Individuals perceive this *meta-problem* and, according to the purposeful communication narrative of STOPS, become motivated to communicate and overcome it. In this context, this research first set out to investigate the individuals' situational perceptions and communicative behaviour concerning the

issue of Natech risk information deficiency to understand the underlying influential factors. Attempting to identify and analyse any potential divergences in how individuals from comparable sociocultural contexts, but embedded in different chemical risk governance systems, communicate about Natech risk information disclosure, we conducted a cross-national, comparative study between Japan and S. Korea. Literature review revealed that there are only a few cross-national risk perception and communication studies that focus on comparisons between Asian countries, which essentially further enhances the academic significance of this study. Moreover, Japan and S. Korea prove to be good candidate countries based on past research, because of their relative similarities in terms of organisational culture. Considering the nature of our enquiry, we turned to audience-based risk communication approaches in order to focus on how citizens receive and respond to chemical risk communication messages. Public relations offered a fresh conceptualisation through STOPS that allowed us to capture situational motivation and analyse the communicative behaviour of individuals concerning the issue of Natech risk information disclosure. Furthermore, we employed OPR dimensions so as to measure how trust and perceived decision-making power-sharing affect citizens' perceptions and motivation to communicate, and looked at additional, potentially influencing factors such as Natech accident risk perception, certain social norms and perceived drawbacks of chemical risk information disclosure.

We collected data from households near prominent industrial parks in Osaka and Kobe in Japan, and Yeosu, Suncheon, Gwangyang and Ulsan in S. Korea. The originality of our approach to such a delicate topic, required a careful evaluation of the methodological tools employed. Hence, our investigation begun from exploring a few key factors that have an impact on the subsequent analysis methods. The preliminary analysis revealed certain differences between the demographic profiles of our two samples that warranted further examination. As far as the performance of the structural equation models is concerned, the analysis exposed some validity concerns for the latent construct of constraint recognition, but the overall goodness-of-fit for the STOPS and OPR models was deemed satisfactory. Group comparison, result interpretation and hypothesis testing were conducted in the following part of the chapter. For both samples, the STOPS model confirmed that citizens' perceived problem severity and personal involvement correlated positively with their situational motivation to communicate, while constraint recognition significantly reduced it. Furthermore, situational motivation seems to be the main driver for communicative action for the *meta-problem* of Natech risk information deficiency, as originally conceptualised. Additionally, all auxiliary hypotheses that were tested in order to assess the validity of STOPS were confirmed. Also, our evidence suggested that trust in government and business organisations and perceived decision power-sharing seem to have a positive effect on

citizens' situational motivation to communicate about Natech risk information disclosure. Our survey comparisons revealed that Natech accident risk is perceived as a significant issue in Japan and S. Korea. However, even though households from both countries recognise the *meta-problem* of Natech risk information deficiency as concerning, Japanese are significantly more constrained in addressing it through communicating. In contrast, Korean respondents seemed to be more communicatively active about it, and more confident in responding to potential Natech accidents. We argue that the chemical risk information regulation framework in S. Korea has probably contributed positively in alleviating the *meta-problem* of risk information deficiency. Moreover, we observed that both organisational trust and control mutuality were substantially increased in S. Korea. Concerns such as a negative impact on the local economy or distrust towards businesses and risk managing authorities, were noted among others as significant challenges for Natech risk communication. Finally, participants were segmented into four types of publics, according to their situational perception about the problem. More than eight out of ten Japanese and Korean citizens expressed high motivation in engaging in communicative actions pertaining to the Natech risk information deficiency problem. The practical implications for policymakers considering the evidenced community 'appetite' for chemical risk information entail regulatory reforms that enhance transparency and encourage citizen engagement.

In Chapter 4, we explored in more depth the decisive sociocultural factors that potentially shape public perceptions concerning the problem of Natech risk information deficiency. Based on the same *meta-problem* framing introduced in the previous chapter, this study attempted to contribute to the risk perception literature from the emerging perspective of Natech accident risk. We utilised the data from the cross-national household survey around prominent industrialised regions of Japan and S. Korea in order to assess the effects of factors such as gender, age, household size, income and educational level on individuals' situational perceptions through the interpretative framework of STOPS. Aligning with the findings of previous studies, the results of our regression analysis indicated in general weak and insignificant effects, except for gender and age that suggested respectively negative and positive influences on individuals' perceptions and motivation to communicate. The implications of the institutional differences between the two countries emerged once again as potential deciding factors within the sphere of chemical and Natech risk communication.

Lastly, Chapter 5 introduced *EGNARIA: an Educational Game for Natech Risk Awareness*, a novel, educational, role-playing board game to raise Natech risk awareness. Considering the evidence from our previous analysis suggesting that individuals are motivated to become informed and communicate about Natech accident risk, and aligning with the current risk communication

paradigm which promotes participatory approaches that extend the disaster risk management discourse to the involve the public, this research explored the potential of serious gaming for Natech risk communication. The game was designed with the aim of raising community awareness about Natech, and generating a discussion among stakeholders about risk management strategies, chemical information disclosure and risk-informed decision-making concerning Natech accidents. In order to assess its impact a quasi-experiment with Kyoto University affiliates was conducted, utilising a survey based on STOPS measures—among others—to understand the game's influence on the participants' communication behaviour regarding Natech risk. The preliminary findings from the game trial suggested an overall positive reception from participants as an engaging, educational tool that can be used to introduce communities to Natech accident risk and discuss about how it is managed. Participants noted that the game raised their awareness about Natech accidents, highlighted the importance of community participation and chemical information disclosure and positively affected their intentions to actively search for and share information about Natech risk. Therefore, *EGNARIA* seemed to fulfil its intended purpose, offering a new serious game-based approach for Natech risk communication that aspires to become a useful tool for disaster risk management researchers and practitioners.

6.1 Limitations

This study attempted to identify and address methodological issues throughout the research process, especially so in view of the conceptual framework used for the cross-national comparison. As explained in Chapter 3, STOPS was employed for the first time in the context of pre-event risk communication and for the purposes of a cross-national comparison within the area of Natech risk communication. This actually elevated the importance of testing the performance of the STOPS model to a secondary academic pursuit. The arguments for the consideration of STOPS as a valid measure to assess residents' communicative behaviour for chemical and Natech risk communication in the Japanese and S. Korean sociocultural context have been highlighted accordingly. As one of the very few studies in the emerging field of Natech risk communication, we hope the findings of this research can contribute to delineating directions for further investigations. At the same time, however, several drawbacks arose during our analysis that should be discussed here with an outlook to future research.

First and foremost, adopting a conceptual model as a representation of the reality is debatable. Several researchers find such positivistic approaches questionable. Irrespective of the statistical assessment of the model's ability to explain the variance observed in the dataset, there may be influencing factors that have been excluded from the analysis. This study acknowledges that the original conceptualisation and application of STOPS in the given context might have

omitted important factors. In any case, the empirical validation of the model does not suggest confirmed causal relationships among the variables under investigation. This framework constitutes an approach to comprehend the citizens' perceptions about the problem of Natech risk information deficiency, not a depiction of the actual multifaceted situation. Additional research is needed to delineate a more comprehensive picture of the potential influencing factors for Natech risk communication; perhaps future works may consider expanding on the presented STOPS and OPR models used in this study by borrowing conceptual constructs from other approaches or proposing new ones.

Then, there were issues with the observed variables. For instance, the latent variable of Constraint Recognition (CR) never achieved the required construct reliability threshold, even after dropping the most troublesome item. Despite falling just short of the strict reliability thresholds, it was retained in the application of the STOPS model in order to better understand and compare Natech risk communication challenges between Japan and S. Korea. Nonetheless, this limitation may stem from the measurement tool, and more precisely the item phrasing, rather the conceptual framework itself. Arguably, asking citizens '*what are your perceived obstacles in resolving this problem*' for a convoluted and multifaceted issue such as Natech risk information disclosure with a mere three questions expecting straightforward results is quite ambitious. Even the different data collection methods (post mail in Japan versus online survey in S. Korea) may have created additional challenges in this regard. Future research is advised to pay attention on how perceived obstacles about this subject are carefully measured to overcome such drawbacks.

Moreover, there was no intention of conducting a cross-cultural study that would involve sociocultural constructs, and would focus on comparing the two samples, even at a national level. Arguably, our approach combined responses from individuals of different sociocultural backgrounds, and so introduced—inevitably—some culture-specific biases. We acknowledge that our efforts to address this issue with the introduction of a single control variable are far from optimal. Our questionnaire survey was already quite long and would not allow us to include extra items for sociocultural measures without risking overburdening our respondents. In this respect, this research topic would greatly benefit from a full-fledged cross-cultural study that would incorporate sociocultural dimensions to effectively capture and disambiguate their influences on the situational variables.

Furthermore, as far as the cross-national comparison is concerned, we did not optimise our sampling method in pursuit of more representative population samples that would permit generalisations and a comparison at the national level between Japan and S. Korea. In contrast, we opted for rather technical criteria, targeting households under immediate risk from a potential

Natech accident at the neighbouring industrial facilities. Resource limitations did not permit the implementation of a sampling strategy that would simultaneously control for the location and the demographic profile of respondents, thus resulting in notable demographic discrepancies between the two samples. Hence, future researchers are encouraged to investigate the topic using different sampling techniques (*e.g.*, stratified sampling) based on demographic criteria (*e.g.*, gender, age, education, income, and so forth), especially if aiming for accurate inter-group comparisons across regions. Finally, our study did not explore the potential influence of survey participation incentives on the quality of responses in an opinion questionnaire about disaster risk communication and perception. Likewise, more studies are required to appreciate the effects of such aspects.

Considering the research limitations pertaining to the *EGNARIA*'s trial application we have to note the lack of population representation. Due to practical restrictions, our sample included only highly-educated, young individuals, and as such cannot be considered as a community workshop trial under realistic conditions. Moreover, an individual trial with only nine participants, although allowed for an in-depth group discussion of the game's learning outcomes, provides arguably little support to *EGNARIA* as a tested community workshop method. Even though our preliminary evidence serves as proof of concept for this novel—yet promising—Natech risk communication tool, further trials in various real-world, community settings are needed to establish its success as a participatory Natech risk management approach.

As with any research project, there are numerous challenges one must face in order to complete the involved tasks; some of them may be successfully circumvented, but compromises are sometimes inevitable. It is noteworthy however, that the level of difficulty in identifying and overcoming these challenges is raised substantially in pioneering approaches. Prior scientific knowledge applicable to an innovative method is scarce and cannot serve as a reference point in order to better identify and address issues. Part of the limitations of this study can actually be attributed to this argument. As explained above, this attempt is not perfect, but given the circumstances it constitutes an admirable first try. Refinement of the methods is needed, of course.

6.2 Research Outlook

Chemical and Natech risk communication can be a fertile ground for new research, since it has not received much academic attention so far. Japan is not the first and certainly not the last country that faces risk communication challenges pertaining to community right-to-know and information disclosure. Furthermore, by riding on this new wave of participatory, bottom-up approaches in risk management, future researchers are encouraged to explore risk management issues from the perspective of the community. As indicated by the literature review the subject has

been touched upon mainly from the standpoint of risk perception, but since risk communication is the vital element, perhaps public relations approaches, similar to this, deserve as much of a chance. Moreover, more qualitative research approaches may help to disentangle the issue of Natech risk communication and information disclosure, especially when attempting to disambiguate and analyse its complexity from a lay public and community perspective. Also, this study did not consider particularly the sources or the channels of risk communication and what effect they may have on the public's perceptions and communicative behaviour. Future studies may investigate how individuals seek out and exchange information about Natech risk and whether different communication channels affect their behaviour. Further research to expand our understanding on how Natech risk information is processed and what are the motivating factors that lead to preparedness and protective actions is equally important from a risk reduction standpoint.

An invaluable trait of STOPS, as demonstrated through this study, is the dynamic for comparative studies. Expanding on this, a more in-depth analysis of the individuals' communicative behaviour patterns can be conducted using STOPS as a research framework to collect data from different regions within Japan or even across the globe. Findings can then be compared against the results of our study in order to better understand citizens' communicative attitude towards chemical risk information disclosure, and perhaps even delineate any emerging patterns. Likewise, future studies can examine whether foreign residents and tourists have different opinions concerning Natech risk information disclosure, considering their diverse cultural background and potential communication difficulties. Foreigners were not the target of this current survey and thus were vastly underrepresented. Furthermore, as evidenced by this study, the effect of the sociocultural environment on this chemical risk information 'appetite' should not be neglected by future researchers. Thus, going beyond our comparison between Japan and S. Korea, STOPS offers a great opportunity for cross-cultural studies across other countries that would elucidate how culturally different mindsets approach the issue of Natech risk communication.

Apart from the research opportunities presented by the application of STOPS, the actual issue of participatory risk management is also worth of academic attention. In particular, engaging the community is only part of the whole process, which involves governments and businesses, as well. Therefore, the challenge still lies in investigating whether there are significant 'resistances' to publicly disclose chemical and Natech risk information from the perspective of the administrative institutions and the industries and what are they attributed to. Improving organisation-public relations seems to contribute in the direction of participatory risk management, however, more research is needed in order to better appreciate the underlying effects of such elements in shaping risk perceptions and fostering risk communication practices. Similar to the

Natech risk communication field, implementation science for Natech risk management is still at its infancy; this leads us to the following point.

Considering future directions of the serious game, further trials are needed in order to assess its impact on communities, with special attention to population representation—as explained. The original version of *EGNARIA* was developed in English, considering an earthquake-prone and tsunami-prone coastal region, and with specific chemical substances. For future applications, *EGNARIA* can be updated to include more and/or different types of chemicals or triggering natural hazards, so that the participants will be introduced to different chemical scenarios related to them. Also, a different version of *EGNARIA* can be created with reference to another environment or geographic area. Likewise, *EGNARIA* materials can be translated in other languages with respect to specific terminology in order to enhance the game's accessibility to broader audiences.

This research is by no means a comprehensive and exhaustive cross-cultural analysis of the citizen's communication behaviour for chemical risk information in Japan and S. Korea. On the contrary, it was a primordial attempt to appreciate the situation from the community's perspective, instead of arbitrarily deciding on what is beneficial for the local residents and imposing a top-down regulatory framework for chemical risk management that pays little respect to their willingness to participate. Hopefully, this work will become a beacon for future research directions which will elucidate to a greater extent the topics pertaining to participatory chemical accident risk this study only touched upon. With some luck, the discoveries from this research—as well those that follow it—will spark a transformation in technological risk management and communication practices in Japan and around the world, towards more inclusive and participatory decision-making processes.

Appendix

A.1 Statistical Tables

Table A.1-1 Survey Distribution Districts and Response Rate

Country	City (shi)	Ward (ku)	Town (cho/machi) and District (chome)	Registered Addresses	Sum	Responses	Rate (%)	Sum	Rate (%)
Japan	Kobe 神戸市	Higashinada 東灘区	Sumiyoshi Minamimachi 1-chome	306	1,193	39	12.75%	135	11.32%
		Higashinada 東灘区	Mikagehonmachi 3-chome	243		20	8.23%		
		Higashinada 東灘区	Mikagehonmachi 5-chome	203		17	8.37%		
		Higashinada 東灘区	Mikagehonmachi 7-chome	195		19	9.74%		
		Higashinada 東灘区	Nishiokamoto 7-chome	246		40	16.26%		
	Sakai 堺市	Sakai 堺区	Kashiwagicho 3-chome	146	573	11	7.53%	63	10.99%
		Sakai 堺区	Kashiwagicho 4-chome	177		17	9.60%		
		Sakai 堺区	Shijodori	250		35	14.00%		
	Takaishi 高石市	–	Takashinohama 2-chome	317	864	45	14.20%	130	15.05%
		–	Takashinohama 4-chome	547		85	15.54%		
Japan Total					**2,630**	**328**	**12.47%**	**328**	**12.47%**
South Korea	Ulsan	Ulsan		150	300	150	100%	300	100%
	Jeollanam-do	Yeosu-si		63		63	100%		
		Suncheon-si		58		58	100%		
		Gwangyang-si		29		29	100%		
S. Korea Total					**300**	**300**	**100%**	**300**	**100%**

Source: Original work

Table A.1-2 Summary of Demographic Characteristics of the Respondents

Category	**Country**		**Total**	
	Japan	**S. Korea**		
	51,38%	48,62%	617	100%
Gender				
Female (1)	41,01%	43,33%	260	42,14%
Male (2)	57,73%	61,00%	366	59,32%
Age				
19 or younger (1)	0,32%	0,33%	2	0,32%
20 – 29 (2)	2,21%	2,33%	14	2,27%
30 – 39 (3)	9,15%	9,67%	58	9,40%
40 – 49 (4)	11,99%	12,67%	76	12,32%
50 – 59 (5)	17,03%	18,00%	108	17,50%
60 – 74 (6)	41,96%	44,33%	266	43,11%
75 or older (7)	16,72%	17,67%	106	17,18%
Educational Level				
Elementary School (1)	2,21%	2,33%	14	2,27%
High School (2)	35,65%	37,67%	226	36,63%
Vocational / Technical School (3)	14,83%	15,67%	94	15,24%
Bachelor Degree (4)	33,44%	35,33%	212	34,36%
Master Degree / PhD (5)	8,52%	9,00%	54	8,75%
Annual Household Income Level				
Low (0)	35,33%	37,33%	224	36,30%
Middle (1)	30,91%	32,67%	196	31,77%
High (2)	23,03%	24,33%	146	23,66%
Household Size				
1 Member (1)	17,35%	18,33%	110	17,83%
2 Members (2)	37,54%	39,67%	238	38,57%
3 Members (3)	22,08%	23,33%	140	22,69%
4 Members (4)	12,62%	13,33%	80	12,97%
5 Members (5)	4,10%	4,33%	26	4,21%
6 Members (6)	1,58%	1,67%	10	1,62%
7 or more (7)	0,32%	0,33%	2	0,32%
Spouse				
No (0)	29,02%	30,67%	184	29,82%
Yes (1)	65,62%	69,33%	416	67,42%
Children				
No (0)	55,21%	58,33%	350	56,73%
Yes (1)	40,69%	43,00%	258	41,82%
N= 617				

Source: Original work

Table A.1-3 Summary of Key Demographic Characteristics of the Population

Japan	***Mean Age***	***Gender Ratio***	***Average Household Size***	***Children in Household***	***Foreigner Household Ratio***
Higashinada-ku 東灘区	44.79	–	2.17	21.90%	–
Kobe-shi 神戸市	–	.91	–	–	.03
Sakai-ku 堺区	46.92	–	2.08	17.74%	–
Sakai-shi 堺市	–	.93	–	–	.02
Takaishi 高石市	46.00	–	2.46	25.03%	–

Income †		***Marital Status*** ‡	
Below ¥3,000,000	39.68%	*Never Married*	36.22%
¥3,000,001 – ¥6,000,000	35.67%	*Married*	48.83%
Over ¥6,000,001	24.64%	*Widowed*	6.59%
		Divorced	5,01%
		N/A	3,34%

Notes: No response (N/A).

† Kinki Region (近畿).

‡ Average for Kobe-shi (神戸市) and Sakai-shi (堺市).

South Korea	***Mean Age***	***Gender Ratio***	***Average Household Size***	***Average Household Monthly Income***	***Foreigner Household Ratio***
Ulsan	36.0	105.8	2.51	4,642,311 ₩	.02
Yeosu-si	42.7	95.8	2.39		.01
Suncheon-si			2.46		.01
Gwangyang-si			2.47		.01

Source: Based on the 2015 Population Census of Japan (Statistics Bureau, 2018), and 2020 Population Census of South Korea (Statistics Korea, 2020)*. Original analysis*

Table A.1-4 Factor and Item Loadings for the Variables of the Initial Structural STOPS Model

Dependent Variable	*Independent Variable*	*Unstandardised Estimate (β)*	*Standardised Estimate (B)*	*Std. Error*	*Probability*
SM	PR	.219	.179	.123	.076
SM	CR	-2.155	-.386	1.037	.038
SM	IR	.264	.285	.107	.014
CAPS	RC	.189	.211	.039	***
CAPS	SM	.701	.837	.056	***
IFrf	CAPS	.629	.629	.072	***
IPrm	CAPS	1	.841	–	–
IFwd	CAPS	.991	.995	.084	***
IShr	CAPS	1.082	.852	.084	***
ISek	CAPS	.821	.681	.084	***
IAtt	CAPS	.852	.796	.082	***
RC1	RC	1	.818	–	–
RC2	RC	1.071	.842	.092	***
RC3	RC	.407	.302	.082	***
PR1	PR	1	.848	–	–
PR2	PR	1.034	.886	.054	***
PR3	PR	1.007	.799	.06	***
SM1	SM	1	.853	–	–
SM2	SM	.891	.692	.065	***
SM3	SM	.977	.841	.054	***
CR1	CR	1	.148	–	–
CR2	CR	3.492	.513	1.55	.024
CR3	CR	1	.941	–	–
IR1	IR	.914	.901	.035	***
IR2	IR	.93	.779	.049	***
IR3	IR	1	.767	–	–
IFrf1	IFrf	.999	.656	.091	***
IFrf2	IFrf	1.172	.852	.09	***
IFrf3	IFrf	1	.842	–	–
IPrm1	IPrm	1.1	.884	.063	***
IPrm2	IPrm	.436	.451	.055	***
IPrm3	IPrm	1.056	.745	.085	***
IFwd1	IFwd	.898	.639	.084	***
IFwd2	IFwd	1	.699	–	–
IFwd3	IFwd	1	.886	–	–
IShr1	IShr	.883	.782	.052	***
IShr2	IShr	.941	.852	.048	***
IShr3	IShr	1	.825	–	–
ISek1	ISek	1.063	.877	.072	***
ISek2	ISek	.685	.524	.075	***
ISek3	ISek	1	.722	–	–
IAtt1	IAtt	1.011	.827	.074	***
IAtt2	IAtt	.966	.872	.068	***
IAtt3	IAtt	4.237	.591	1.864	.023

N=617

**** Estimate significant at the .001 level (2-tailed).*

Notes: Problem Recognition (PR), Involvement Recognition (IR), Constraint Recognition (CR), Referent Criteria (RC), Situational Motivation (SM), Information Forefending (IFrf), Information Sharing (IShr), Information Forwarding (IFwd), Information Seeking (ISek), Information Attending (IAtt), Information Permitting (IPrm) and Communicative Action in Problem Solving (CAPS).

Source: Original work

Table A.1-5 Factor and Item Loadings for the Variables of the Final Measurement STOPS Model

Dependent Variable	*Independent Variable*	*Unstandardised Estimate (β)*	*Standardised Estimate (B)*	*Std. Error*	*Probability*
SM	PR	.312	.255	.119	.009
SM	CR	-.625	-.23	.212	.003
SM	IR	.384	.415	.093	***
CAPS	RC	.123	.149	.035	***
CAPS	SM	.691	.899	.06	***
IFrf	CAPS	.627	.576	.08	***
IPrm	CAPS	1.106	.865	.101	***
IFwd	CAPS	1	.97	–	–
IShr	CAPS	1.135	.823	.087	***
ISek	CAPS	.754	.526	.098	***
IAtt	CAPS	.955	.805	.099	***
RC1	RC	1	.813	–	–
RC2	RC	1.086	.85	.095	***
RC3	RC	.406	.3	.083	***
PR1	PR	1	.847	–	–
PR2	PR	1.035	.887	.054	***
PR3	PR	1.007	.799	.06	***
SM1	SM	1	.851	–	–
SM2	SM	.871	.673	.065	***
SM3	SM	.991	.851	.054	***
CR1	CR	2.456	.74	.634	***
CR2	CR	1	.304	–	–
IR1	IR	1	.941	–	–
IR2	IR	.915	.902	.035	***
IR3	IR	.927	.777	.049	***
IFrf1	IFrf	1	.801	–	–
IFrf2	IFrf	.954	.625	.087	***
IFrf3	IFrf	1.105	.802	.077	***
IPrm1	IPrm	1	.831	–	–
IPrm2	IPrm	1.12	.888	.061	***
IPrm3	IPrm	.458	.467	.055	***
IFwd1	IFwd	1.148	.77	.099	***
IFwd2	IFwd	.878	.594	.094	***
IFwd3	IFwd	1	.664	–	–
IShr1	IShr	1	.885	–	–
IShr2	IShr	.887	.783	.052	***
IShr3	IShr	.94	.849	.048	***
ISek1	ISek	1	.898	–	–
ISek2	ISek	.936	.84	.058	***
IAtt1	IAtt	1	.733	–	–
IAtt2	IAtt	.982	.817	.07	***

Notes: Problem Recognition (PR), Involvement Recognition (IR), Constraint Recognition (CR), Referent Criteria (RC), Situational Motivation (SM), Information Forefending (IFrf), Information Sharing (IShr), Information Forwarding (IFwd), Information Seeking (ISek), Information Attending (IAtt), Information Permitting (IPrm) and Communicative Action in Problem Solving (CAPS).

Source: Original work

Table A.1-6 Factor and Item Loadings for the Variables of the Final Measurement OPR-Situational Perception Model

Dependent Variable	***Independent Variable***	***Unstandardised Estimate (β)***	***Standardised Estimate (B)***	***Std. Error***	***Probability***
CR	CM	-.418	-.457	.082	***
IR	OT	-.796	-.624	.252	.002
PR	OT	-.248	-.25	.062	***
IR	CM	.658	.5	.25	.008
SM	PR	.309	.253	.105	.003
SM	CR	-.256	-.188	.103	.013
SM	IR	.391	.413	.086	***
PR1	PR	.965	.858	.05	***
PR2	PR	1	.893	–	–
PR3	PR	.941	.778	.057	***
IR1	IR	1	.955	–	–
IR2	IR	.894	.895	.034	***
IR3	IR	.899	.765	.048	***
CR1	CR	1	.626	–	–
CR2	CR	.595	.375	.161	***
OT3ii	OT	1.344	.942	.096	***
OT3i	OT	1.12	.799	.091	***
OT2ii	OT	1.204	.817	.095	***
OT2i	OT	1.031	.68	.085	***
OT1ii	OT	1.19	.812	.07	***
OT1i	OT	1	.65	–	–
CM3ii	CM	1.163	.819	.081	***
CM3i	CM	.945	.66	.082	***
CM2ii	CM	1.332	.943	.081	***
CM2i	CM	1.025	.766	.061	***
CM1ii	CM	1.209	.853	.05	***
CM1i	CM	1	.715	–	–
SM1	SM	1	.891	–	–
SM2	SM	.844	.683	.064	***
SM3	SM	.899	.808	.055	***

N=617

Notes: Problem Recognition (PR), Involvement Recognition (IR), Constraint Recognition (CR), Referent Criteria (RC), Situational Motivation (SM), Organisational Trust (OT) and Control Mutuality (CM) ('i' targeted at government and 'ii' targeted at industries).

Source: Original work

Table A.1-7 Descriptive Statistics for Imputed Latent Variables

Variable	***Mean (μ)***	***Std. Deviation (σ)***	***Skewness***	***Std. Error***	***Kurtosis***	***Std. Error***
PR	5.814	.966	-1.206	.098	2.407	.196
IR	5.260	1.153	-.741	.098	.600	.196
CR	4.404	1.281	-.260	.098	-.375	.196
RC	3.734	1.207	.195	.098	-.319	.196
SM	4.558	1.185	-.367	.098	.019	.196
IFrf	3.122	1.363	.449	.098	-.395	.196
IPrm	4.709	1.104	-.473	.098	.207	.196
IFwd	4.015	1.182	-.237	.098	-.174	.196
IShr	4.285	1.214	-.417	.098	.051	.196
ISek	3.580	1.313	.168	.098	-.474	.196
IAtt	4.897	1.109	-.566	.098	.564	.196
OT	3.809	1.250	-.150	.098	-.214	.196
CM	3.484	1.239	.059	.098	-.336	.196

N=617

Notes: Problem Recognition (PR), Involvement Recognition (IR), Constraint Recognition (CR), Referent Criteria (RC), Situational Motivation (SM), Information Forefending (IFrf), Information Sharing (IShr), Information Forwarding (IFwd), Information Seeking (ISek), Information Attending (IAtt), Information Permitting (IPrm), Communicative Action in Problem Solving (CAPS), Organisational Trust (OT) and Control Mutuality (CM).

Source: Original work

Table A.1-8 Cook's Distance for Imputed Latent Variables

Regression		***Maximum Cook's Distance***
Dependent Variable	*Independent Variable*	
SM	**PR**	.19134
	IR	.12092
	CR	.07567
CAPS	**RC**	.22999
	SM	.11039
IFrf	**CAPS**	.14809
IShr	**CAPS**	.05837
IFwd	**CAPS**	.04593
ISek	**CAPS**	.03261
IAtt	**CAPS**	.07026
IPrm	**CAPS**	.07564
PR	**OT**	.04586
	CM	.05995
IR	**OT**	.04956
	CM	.06302
CR	**OT**	.05119
	CM	.05221
Criteria		***>1.0***

N=617

Notes: Problem Recognition (PR), Involvement Recognition (IR), Constraint Recognition (CR), Referent Criteria (RC), Situational Motivation (SM), Information Forefending (IFrf), Information Sharing (IShr), Information Forwarding (IFwd), Information Seeking (ISek), Information Attending (IAtt), Information Permitting (IPrm), Communicative Action in Problem Solving (CAPS), Organisational Trust (OT) and Control Mutuality (CM).

Source: Original work

Table A.1-9 Descriptive Statistics for Questionnaire Items

Item	***Mean (μ)***	***Mode***	***Std. Deviation (σ)***	***Skewness***	***Std. Error***	***Kurtosis***	***Std. Error***
NT1	6.04	7	1.060	-1.461	.098	2.806	.196
NT2	5.60	6	1.302	-1.108	.098	.992	.196
NT3	5.64	6	1.190	-.965	.098	.728	.196
NT4	5.88	6	1.124	-1.159	.098	1.322	.196
NT5	3.36	2	1.653	.267	.098	-.923	.196
NT6	4.93	5	1.276	-.338	.098	.032	.196
PR1	5.91	6	1.112	-1.265	.098	2.154	.196
PR2	5.97	6	1.078	-1.372	.098	2.556	.196
PR3	5.56	6	1.142	-.866	.098	.895	.196
IR1	5.39	6	1.274	-.818	.098	.542	.196
IR2	5.49	6	1.210	-.896	.098	.848	.196
IR3	4.89	5	1.430	-.427	.098	-.269	.196
CR1	4.64	4	1.556	-.309	.098	-.541	.196
CR2	4.17	4	1.473	-.079	.098	-.639	.196
CR3	3.08	2	1.476	.568	.098	-.285	.196
RC1	3.26	2	1.499	.358	.098	-.567	.196
RC2	3.52	4	1.578	.243	.098	-.680	.196
RC3	4.42	5	1.448	-.379	.098	-.390	.196
SM1	4.93	5	1.315	-.618	.098	.194	.196
SM2	3.82	4	1.538	.009	.098	-.586	.196
SM3	4.92	5	1.303	-.641	.098	.273	.196
IFrf1	2.81	1	1.565	.623	.098	-.428	.196
IFrf2	3.60	4	1.561	.008	.098	-.781	.196
IFrf3	2.95	2	1.560	.552	.098	-.536	.196
IPrm1	4.60	5	1.329	-.489	.098	.073	.196
IPrm2	4.71	5	1.444	-.621	.098	-.109	.196
IPrm3	4.82	5	1.239	-.541	.098	.221	.196
IFwd1	4.30	4	1.425	-.262	.098	-.306	.196
IFwd2	3.50	4	1.477	.191	.098	-.525	.196
IFwd3	4.24	4	1.399	-.461	.098	-.149	.196
IShr1	4.10	4	1.384	-.239	.098	-.149	.196
IShr2	4.56	5	1.379	-.551	.098	.070	.196
IShr3	4.19	4	1.365	-.284	.098	-.239	.196
ISek1	3.37	4	1.644	.196	.098	-.821	.196
ISek2	3.26	4	1.543	.247	.098	-.744	.196
ISek3	4.11	4	1.572	-.110	.098	-.738	.196
IAtt1	4.71	5	1.414	-.685	.098	.181	.196
IAtt2	4.87	5	1.225	-.653	.098	.597	.196
IAtt3	5.11	5	1.224	-.665	.098	.550	.196
JKN1	3.48	2	1.728	.198	.098	-1.018	.196
JKN2	4.44	6	1.608	-.442	.098	-.660	.196
JKN3	3.92	4	1.680	-.119	.098	-.845	.196
OC1	5.53	6	1.135	-.844	.098	.878	.196
OC2	5.08	6	1.311	-.606	.098	.044	.196
OC3	5.55	6	1.116	-.867	.098	.951	.196
OC4	4.93	5	1.276	-.338	.098	.032	.196
OT1i	3.59	4	1.568	.032	.098	-.793	.196
OT1ii	3.50	3	1.513	.253	.098	-.547	.196
OT2i	4.13	4	1.561	-.316	.098	-.521	.196
OT2ii	4.20	4	1.499	-.230	.098	-.489	.196
OT3i	3.75	4	1.541	-.060	.098	-.747	.196

Item	Mean (μ)	Mode	Std. Deviation (σ)	Skewness	Std. Error	Kurtosis	Std. Error
OT3ii	3.70	3	1.486	.083	.098	-.578	.196
CM1i	3.62	4	1.465	-.074	.098	-.576	.196
CM1ii	3.61	4	1.434	.104	.098	-.418	.196
CM2i	3.51	4	1.504	.095	.098	-.592	.196
CM2ii	3.47	3	1.423	.245	.098	-.400	.196
CM3i	3.40	3	1.488	.144	.098	-.522	.196
CM3ii	3.30	3	1.459	.316	.098	-.379	.196

N=617

Notes: Natech Risk Perception (NT), Problem Recognition (PR), Involvement Recognition (IR), Constraint Recognition (CR), Referent Criteria (RC), Situational Motivation (SM), Information Forefending (IFrf), Information Sharing (IShr), Information Forwarding (IFwd), Information Seeking (ISek), Information Attending (IAtt), Information Permitting (IPrm), Social Norms(JKN), Other Constraints (OC), Organisational Trust (OT) and Control Mutuality (CM) ('i' targeted at government and 'ii' targeted at industries).

Source: Original work

Table A.1-10 Correlation Matrix, Means, and Standard Deviations for STOPS Items

	PR1	PR2	PR3	IR1	IR2	IR3	CR1	CR2	RC1	RC2	RC3	SM1	SM2	SM3	IFrf1	IFrf2	IFrf3	IPrm	IPrm	IPrm	IFwd	IFwd	IFwd	IShr1	IShr2	IShr3	ISek1	ISek2	IAtt1	IAtt2	IAtt3
Mean	5.91	5.97	5.56	5.39	5.49	4.89	4.64	4.17	3.26	3.52	4.42	4.93	3.82	4.92	2.81	3.60	2.95	4.60	4.71	4.82	4.30	3.50	4.24	4.10	4.56	4.19	3.37	3.26	4.71	4.87	5.11
Std. Dev.	1.112	1.078	1.142	1.274	1.210	1.430	1.556	1.473	1.499	1.578	1.448	1.315	1.538	1.303	1.565	1.561	1.560	1.329	1.444	1.239	1.425	1.477	1.399	1.384	1.379	1.365	1.644	1.543	1.414	1.225	1.224
PR1	1																														
PR2	.710**	1																													
PR3	.599**	.600**	1																												
IR1	.566**	.568**	.592**	1																											
IR2	.544**	.595**	.531**	.757**	1																										
IR3	.451**	.433**	.462**	.674**	.592**	1																									
CR1	-.020	-.014	-.003	-.171**	-.109**	-.284**	1																								

IFwd2	IFwd1	IPrm3	IPrm2	IPrm1	IFrf3	IFrf2	IFrf1	SM3	SM2	SM1	RC3	RC2	RC1	CR2	
.089*	.272**	.199**	.354**	.304**	-.033	.018	.001	.383**	.240**	.415**	.096*	-.024	-.056	.080*	PR1
.071	.292**	.173**	.362**	.342**	-.037	.050	-.009	.388**	.228**	.368**	.079*	-.012	-.057	.087*	PR2
.065	.252**	.217**	.374**	.306**	-.015	-.008	.012	.347**	.248**	.370**	.068	-.021	-.086*	.051	PR3
.216**	.389**	.208**	.405**	.390**	.103*	.124**	.176**	.424**	.385**	.474**	.043	.135**	.082*	.025	IR1
.180**	.345**	.207**	.390**	.406**	.090*	.080*	.129**	.404**	.329**	.444**	.031	.063	.042	.031	IR2
.327**	.401**	.222**	.385**	.397**	.187**	.187**	.256**	.427**	.472**	.507**	.093*	.164**	.162**	-.042	IR3
-.480**	-.326**	-.040	-.182**	-.225**	-.478**	-.426**	-.576**	-.170**	-.407**	-.214**	-.221**	-.467**	-.515**	.430**	CR1
-.282**	-.199**	-.061	-.094*	-.121**	-.330**	-.258**	-.312**	-.054	-.207**	-.043	-.229**	-.263**	-.268**	1	CR2
.530**	.308**	.028	.179**	.218**	.602**	.569**	.632**	.151**	.441**	.214**	.292**	.717**	1		RC1
.482**	.271**	-.036	.125**	.223**	.531**	.473**	.581**	.181**	.450**	.220**	.354**	1			RC2
.230**	.140**	.140**	.145**	.116**	.303**	.220**	.304**	.165**	.269**	.221**	1				RC3
.385**	.544**	.361**	.529**	.565**	.274**	.322**	.314**	.703**	.612**	1					SM1
.593**	.523**	.155**	.355**	.472**	.453**	.417**	.605**	.488**	1						SM2
.346**	.548**	.348**	.595**	.584**	.192**	.303**	.231**	1							SM3
.651**	.417**	.075	.261**	.358**	.715**	.590**	1								IFrf1
.553**	.416**	.145**	.304**	.351**	.619**	1									IFrf2
.565**	.384**	.139**	.293**	.308**	1										IFrf3
.426**	.530**	.391**	.661**	1											IPrm
.328**	.542**	.494**	1												IPrm
.173**	.379**	1													IPrm
.556**	1														IFwd
1															IFwd
															IFwd
															IShr1
															IShr2
															IShr3
															ISek1
															ISek2
															IAtt1
															IAtt2
															IAtt3

	IFwd3	IShr1	IShr2	IShr3	ISek1	ISek2	IAtt1	IAtt2	IAtt3
PR1	.223**	.246**	.276**	.206**	.073	.098*	.281**	.283**	.342**
PR2	.250**	.233**	.280**	.179**	.073	.079*	.265**	.282**	.351**
PR3	.224**	.248**	.247**	.226**	.039	.082*	.208**	.235**	.309**
IR1	.336**	.327**	.321**	.282**	.191**	.196**	.295**	.322**	.349**
IR2	.300**	.314**	.321**	.268**	.165**	.173**	.282**	.313**	.344**
IR3	.334**	.361**	.328**	.353**	.278**	.272**	.299**	.328**	.369**
CR1	-.324**	-.264**	-.206**	-.301**	-.459**	-.480**	-.166**	-.156**	-.104**
CR2	-.131**	-.139**	-.055	-.121**	-.201**	-.248**	-.066	-.024	-.007
RC1	.340**	.303**	.222**	.301**	.541**	.546**	.197**	.152**	.122**
RC2	.342**	.300**	.234**	.274**	.521**	.532**	.157**	.143**	.116**
RC3	.204**	.166**	.083*	.153**	.242**	.298**	.187**	.087*	.126**
SM1	.454**	.486**	.443**	.493**	.350**	.346**	.492**	.513**	.560**
SM2	.505**	.487**	.389**	.448**	.582**	.569**	.367**	.385**	.373**
SM3	.441**	.474**	.446**	.481**	.271**	.289**	.471**	.546**	.564**
IFrf1	.453**	.406**	.281**	.383**	.689**	.682**	.243**	.209**	.189**
IFrf2	.415**	.406**	.356**	.366**	.504**	.506**	.277**	.260**	.228**
IFrf3	.371**	.350**	.265**	.342**	.543**	.545**	.265**	.187**	.146**
IPrm	.504**	.538**	.480**	.530**	.358**	.373**	.474**	.495**	.544**
IPrm	.448**	.475**	.485**	.502**	.266**	.321**	.561**	.534**	.565**
IPrm	.166**	.236**	.297**	.306**	.052	.093*	.339**	.350**	.356**
IFwd	.492**	.525**	.457**	.523**	.440**	.478**	.440**	.487**	.455**
IFwd	.509**	.484**	.411**	.446**	.624**	.596**	.271**	.315**	.290**
IFwd	1	.619**	.549**	.526**	.475**	.467**	.328**	.424**	.384**
IShr1		1	.687**	.698**	.487**	.494**	.388**	.524**	.448**
IShr2			1	.613**	.386**	.370**	.351**	.535**	.475**
IShr3				1	.414**	.446**	.430**	.537**	.446**
ISek1					1	.798**	.336**	.319**	.284**
ISek2						1	.354**	.311**	.309**
IAtt1							1	.561**	.620**
IAtt2								1	.660**
IAtt3									1

Pearson Correlation, N=617
*** Correlation is significant at the .01 level (2-tailed).*
** Correlation is significant at the .05 level (2-tailed).*
Notes: Problem Recognition (PR), Involvement Recognition (IR), Constraint Recognition (CR), Referent Criteria (RC), Situational Motivation (SM), Information Forefending (IFrf), Information Sharing (IShr), Information Forwarding (IFwd), Information Seeking (ISek), Information Attending (IAtt) and Information Permitting (IPrm).

Source: Original work

Table A.1-11 Correlation Matrix, Means, and Standard Deviations for OPR Items and Situational Perception

OT1i	SM3	SM2	SM1	CR2	CR1	IR3	IR2	IR1	PR3	PR2	PR1	Std. Dev.	Mean	
-.104**	.383**	.240**	.415**	.080*	-.020	.451**	.544**	.566**	.599**	.710**	1	1.112	5.91	PR1
-.110**	.388**	.228**	.368**	.087*	-.014	.433**	.595**	.568**	.600**	1		1.078	5.97	PR2
-.133**	.347**	.248**	.370**	.051	-.003	.462**	.531**	.592**	1			1.142	5.56	PR3
-.062	.424**	.385**	.474**	.025	-.171**	.674**	.757**	1				1.274	5.39	IR1
-.079	.404**	.329**	.444**	.031	-.109**	.592**	1					1.210	5.49	IR2
.034	.427**	.472**	.507**	-.042	-.284**	1						1.430	4.89	IR3
-.388**	-.170**	-.407**	-.214**	.430**	1							1.556	4.64	CR1
-.240**	-.054	-.207**	-.043	1								1.473	4.17	CR2
.073	.703**	.612**	1									1.315	4.93	SM1
.209**	.488**	1										1.538	3.82	SM2
.090*	1											1.303	4.92	SM3
1												1.568	3.59	OT1i
												1.513	3.50	OT1ii
												1.561	4.13	OT2i
												1.499	4.20	OT2ii
												1.541	3.75	OT3i
												1.486	3.70	OT3ii
												1.465	3.62	CM1i
												1.434	3.61	CM1ii
												1.504	3.51	CM2i
												1.423	3.47	CM2ii
												1.488	3.40	CM3i
												1.459	3.30	CM3ii

CM3ii	CM3i	CM2ii	CM2i	CM1ii	CM1i	OT3ii	OT3i	OT2ii	OT2i	OT1ii	
-.128**	-.110**	-.159**	-.100*	-.161**	-.116**	-.139**	-.128**	-.042	-.017	-.153**	**PR1**
-.109**	-.106**	-.154**	-.079*	-.141**	-.076	-.111**	-.086*	-.039	-.024	-.136**	**PR2**
-.159**	-.120**	-.174**	-.108**	-.185**	-.123**	-.165**	-.122**	-.111**	-.070	-.186**	**PR3**
-.063	-.049	-.069	-.040	-.069	-.037	-.111**	-.083*	-.013	.006	-.074	**IR1**
-.045	-.048	-.066	-.038	-.097*	-.035	-.110**	-.058	-.013	-.024	-.100*	**IR2**
.005	.030	.014	.046	.013	.019	-.021	.010	.050	.064	.015	**IR3**
-.332**	-.362**	-.365**	-.351**	-.329**	-.307**	-.357**	-.313**	-.249**	-.250**	-.361**	**CR1**
-.320**	-.226**	-.349**	-.230**	-.301**	-.212**	-.326**	-.206**	-.171**	-.102*	-.332**	**CR2**
.040	.057	.047	.070	.065	.072	.012	.034	.138**	.142**	.011	**SM1**
.191**	.174**	.193**	.165**	.196**	.157**	.129**	.125**	.206**	.175**	.175**	**SM2**
.092*	.066	.081*	.067	.072	.086*	.060	.036	.165**	.182**	.051	**SM3**
.517**	.647**	.538**	.681**	.535**	.660**	.551**	.651**	.476**	.541**	.703**	**OT1i**
.663**	.535**	.716**	.543**	.685**	.548**	.697**	.544**	.512**	.422**	1	**OT1ii**
.393**	.579**	.463**	.634**	.473**	.667**	.566**	.719**	.735**	1		**OT2i**
.468**	.457**	.552**	.492**	.552**	.508**	.652**	.566**	1			**OT2ii**
.487**	.713**	.577**	.777**	.591**	.792**	.722**	1				**OT3i**
.663**	.561**	.747**	.575**	.741**	.604**	1					**OT3ii**
.517**	.741**	.594**	.802**	.678**	1						**CM1i**
.692**	.535**	.778**	.549**	1							**CM1ii**
.539**	.798**	.652**	1								**CM2i**
.771**	.603**	1									**CM2ii**
.674**	1										**CM3i**
1											**CM3ii**

Pearson Correlation, N=617
*** Correlation is significant at the .01 level (2-tailed).*
** Correlation is significant at the .05 level (2-tailed).*
Notes: Problem Recognition (PR), Involvement Recognition (IR), Constraint Recognition (CR), Situational Motivation (SM), Organisational Trust (OT) and Control Mutuality (CM) ('i' targeted at government and 'ii' targeted at industries).

Source: Original work

A.2 Sample Questionnaire in Japanese

起こりえる化学事故に関する
ご意見を伺うアンケート

本アンケートにご協力いただきありがとうございます。本研究プロジェクトの目的は、日本の大地震および津波に起因する化学事故（このような事故をナテック事故といいます。）に関するリスク情報開示に対する一般市民が感じる必要性を評価することです。特に今回の調査は、大阪湾沿岸/神戸東灘区の工業地帯（コンビナート）で起こりうるナテック事故の情報開示について、人々がどのようにしてコミュニケーションを図るかに焦点を当てています。

各文の下に記載されている選択肢から、最も同意できるものを選択して、丸をつけて下さい。ご意見を伺うアンケートですので、回答に正解・不正解はありません。正直にお答え頂けると幸いです。

回答には約 25 分かかります。アンケート結果は集計されて、学術的な目的のみによって公表されます。個人が特定されることはありません。無論、このような質問には答えたくないと思われましたら、無理にお答えいただく必要はございません。

このプロジェクトについてより詳しく知りたい場合や議論したい場合は、本研究を担当するジュウジオス・ディミトリオス （メールアドレス：dimitrios.tzioutzios.33x@st.kyoto-u.ac.jp または電話番号：090-23037651）までご連絡ください。

よろしくお願い申し上げます。

Opinion Questionnaire for Potential Chemical Accidents

Thank you very much for participating in this study. The objective of this research project is to assess the necessity of the general public concerning disclosure of risk information about chemical accidents caused by a large earthquake and / or tsunami in Japan. These types of accidents are called Na-Tech accidents. The particular focus of this survey is the communicative action people engage in with regards to the disclosure of information about potential Na-Tech accidents at the industrial park (コンビナート) in the coastal area of Osaka Bay / Higashinada district, Kobe.

Please indicate your level of agreement with each statement by selecting (circling) the appropriate option from the scale provided below each statement. Please answer as honestly as possible. Since this is an opinion questionnaire, there are no correct or incorrect answers. Your cooperation is highly appreciated.

This survey will take about 25 minutes. Please note that your responses are voluntary, anonymous and completely confidential. The data collected will be presented in an aggregated form and published only for academic purposes. Of course, if you think that you do not want to answer such a question, there is no need to forcibly answer.

If you would like to learn more or discuss about this project you may contact the principal investigator Mr. Tzioutzios Dimitrios at the following e-mail address: dimitrios.tzioutzios.33x@st.kyoto-u.ac.jp or telephone number: 090-23037651.

Thank you once again for your participation.

	STATEMENT
	自然災害（大地震や津波など）によって起こりうる化学事故についてお尋ねします。 **Please indicate your level of agreement with the statements concerning potential chemical accidents caused by natural disasters (for example large earthquakes or tsunami).**
NT1	自然災害によって起こりうる化学事故（例えば、福島第一原子力発電所事故）が重要な問題であると考える。 ***I consider potential chemical accidents caused by natural disasters (for example Fukushima Dai-ichi Nuclear Powerplant accident) an important problem.***
	1 全くそう思わない Strongly Disagree　2 そう思わない Disagree　3 あまりそう思わない Somewhat Disagree　4 どちらともいえない Neither Agree nor Disagree　5 ややそう思う Somewhat Agree　6 そう思う Agree　7 とてもそう思う Strongly Agree
NT2	近くの工業地帯で化学事故を引き起こしうる自然災害を心配している。 ***I am concerned about natural disasters causing potential chemical accidents at the nearby industrial park.***
	1 全くそう思わない Strongly Disagree　2 そう思わない Disagree　3 あまりそう思わない Somewhat Disagree　4 どちらともいえない Neither Agree nor Disagree　5 ややそう思う Somewhat Agree　6 そう思う Agree　7 とてもそう思う Strongly Agree
NT3	大規模な地震が発生した場合、私の街の工業地帯で化学事故が発生する可能性があると思う。 ***If a large earthquake happens, I think that a chemical accident could occur at the industrial park in my city.***
	1 全くそう思わない Strongly Disagree　2 そう思わない Disagree　3 あまりそう思わない Somewhat Disagree　4 どちらともいえない Neither Agree nor Disagree　5 ややそう思う Somewhat Agree　6 そう思う Agree　7 とてもそう思う Strongly Agree
NT4	さらにそれらの化学事故によって、近隣住民が直接影響を受ける可能性があると信じている。 ***If a large earthquake causes a chemical accident at the nearby industrial park, I believe the residents could be directly impacted.***
	1 全くそう思わない Strongly Disagree　2 そう思わない Disagree　3 あまりそう思わない Somewhat Disagree　4 どちらともいえない Neither Agree nor Disagree　5 ややそう思う Somewhat Agree　6 そう思う Agree　7 とてもそう思う Strongly Agree
NT5	私は、近くの工業地帯で化学事故が起こった場合にどう対応すればよいか知っている。 ***I believe I know how to respond during a chemical accident at the nearby industrial park.***
	1 全くそう思わない Strongly Disagree　2 そう思わない Disagree　3 あまりそう思わない Somewhat Disagree　4 どちらともいえない Neither Agree nor Disagree　5 ややそう思う Somewhat Agree　6 そう思う Agree　7 とてもそう思う Strongly Agree

	STATEMENT
	これより、[大阪湾沿岸、神戸市東灘区]の工業地帯（コンビナート）で発生する可能性のある化学事故に関する情報が公開されていないという問題について、お尋ねします。 Problem description: **There is a lack of publicly available information about potential chemical accidents at the industrial park (コンビナート) in [the coastal area of Osaka Bay / Higashinada district, Kobe].**
PR1	これは重要な問題だと思う。 ***I think this is an important problem.***
	1 全くそう思わない Strongly Disagree　2 そう思わない Disagree　3 あまりそう思わない Somewhat Disagree　4 どちらともいえない Neither Agree nor Disagree　5 ややそう思う Somewhat Agree　6 そう思う Agree　7 とてもそう思う Strongly Agree
PR2	政府機関はこの問題を解決するための行動を取るべきだ。 ***Government institutions should take action to solve this problem.***

	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
PR3	この問題について、あるべき対応と現状の対応との間に大きなギャップがあると思う。 ***Concerning this problem, I think there is a large gap between the way things should be and the way they are now.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IR1	この問題は私に深刻な影響を与える可能性がある。 ***This problem could have serious consequences for me.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IR2	この問題は私の生活に何らかの影響を与える可能性がある。 ***This problem could make a difference in my daily life.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IR3	自分自身とこの問題の間に強い関係がある。 ***There is a strong relationship between myself and this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
CR1	この問題に関する状況を私が改善できると信じている。 ***I believe I can improve the situation regarding this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
CR2	この問題について私が何か行動を起こすのを妨げる障害はほとんどないと信じている。 ***I believe there are few obstacles preventing me from doing something about this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
CR3	私の意見は、この問題に取り組んでいる政府にとって重要である。 ***My opinions matter to those in the government, who are working on this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
JN1	[堺/高石市/東灘]の住民が化学事故の可能性に関する情報公開を求めることが、他の市民に不快感を引き起こす可能性がある。 ***It could cause discomfort to other citizens, if a resident [of Sakai / Takaishi / Higashinada] asked for information concerning the potential for chemical accidents.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
JN2	将来起こりうる化学事故に関する意思決定に市民が参加することは期待されていない。 ***It is not expected that citizens participate in decisions regarding the potential for chemical accidents.***						

	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
JN3	将来的に起こりうる化学事故に関する情報を政府が隠ぺいすることはないと信頼している。 ***I trust the way the government handles access to information about potential chemical accidents.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
OC1	化学事故の潜在的な影響に関する情報が入手可能になった場合、工業地帯の近くの地域で土地価格は下落するだろう。 ***Land prices would likely drop in areas near the industrial park, if information about the potential consequences of chemical accidents was made available.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
OC2	潜在的な化学事故の影響に関する情報が入手可能になった場合、（堺市/高石市/東灘）の地域経済（例えば、観光、貿易）は影響を受けるだろう。 ***The economy [of Sakai / Takaishi / Higashinada] (for example tourism, trade) would be affected, if information about the consequences of potential chemical accidents was made available.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
OC3	潜在的な化学事故に関する最新情報へアクセスできないことは、市民の問題理解を制限する。 ***Lack of access to updated information about potential chemical accidents, limits citizens' understanding of the problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
OC4	（堺市/高石市/東灘地区）の住民の方（かた）に潜在的な化学事故に関する情報を入手したくない理由がございましたら、ご記入ください。 ***Other reasons why residents [of Sakai / Takaishi / Higashinada] do <u>NOT</u> want information about potential chemical accidents to become available*** *(Please describe).*						
RC1	私はこの問題に対処する方法について明確な考えを持っている。 ***I have a clear idea about how to deal with this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
RC2	私は、政府がこの問題にどのようにアプローチすべきかについて考えがある。 ***I have an idea about how the government should approach this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree

RC3	私は、この問題をどう対処するかについて、日本の他の地域の事例があると信じている。 ***I believe there are examples from other regions in Japan on how to deal with this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
SM1	私はこの問題に関心がある。 ***I am curious about this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
SM2	私は頻繁にこの問題について考える。 ***I frequently think about this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
SM3	この問題をよりよく理解したい。 ***I want to better understand this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IFrf1	私はこの問題について学ぶのに多くの時間と労力を費やした。 ***I have invested a lot of time and energy learning about this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IFrf2	私はこの問題に関する情報の質を判断する能力がある。 ***I am capable of judging information quality about this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IFrf3	私は、この問題に関する情報の更新を確認するための、信頼できる情報源を選択している。 ***I have a selection of trusted sources that I check for updates concerning this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IPrm1	この問題に関するすべての意見に興味がある。 ***I am interested in all views concerning this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IPrm2	私はこの問題について複数の情報源から情報を得たい。 ***I want to know about this problem from multiple sources.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IPrm 3	私はこの問題に関して、私とは反対の意見であっても耳を傾ける。 ***I listen even to opposite views regarding this problem.***						

	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IFwd1	私はこの問題について家族や友人に伝えようとしている。 ***I am trying to inform my family and friends about this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IFwd2	私は頻繁にこの問題について自信を持って意見を述べます。 ***I frequently express my opinions confidently about this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IFwd3	私はこの問題を解決するために、他の人を説得するのに時間を費やす価値があると信じている。 ***I believe it is worth spending some time to persuade others about solving this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IShr1	もし誰かがこの問題について私に尋ねれば、私は是非とも議論したいと思う。 ***I am willing to talk to someone about this problem, if they ask me.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IShr2	もし誰かがこの問題について私に尋ねれば、私は彼らが望むすべての情報を共有しようと思う。 ***If someone asks me about this problem, I am willing to share any information they want.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IShr3	誰かがこの問題を話題に出せば、私はその議論にぜひ参加したいと思う。 ***I like to participate in the discussion about this problem, when others bring up the topic.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
ISek1	私はこの問題に関して、インターネット、新聞、スマホアプリなど何らかのツールを介して積極的に情報を検索している。 ***I actively search for information on the Internet, in newspapers, via mobile applications or otherwise, regarding this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
ISek2	私はこの問題に関する新しい情報があるかどうか定期的にチェックする。 ***I regularly check to see if there is new information about this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
ISek3	私は人々にこの問題に関連する情報提供を求める。 ***I ask people for information related to this problem.***						

	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IAtt1	**私は新聞、ウェブサイト、ソーシャルメディアで記事を見つけたとき、この問題に関連するトピックを読む。** ***I read about topics related to this problem, when I find articles in newspapers, websites or social media.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IAtt2	**誰かがこの問題について話していると、私は彼らがどのような意見を持っているかを慎重に聞く。** ***If someone talks about this problem, I listen carefully to what they have to say.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
IAtt3	**私はこの問題に関する報道に注意を払う。** ***I pay attention to news reports regarding this problem.***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree

	STATEMENT						
	これより、政府および工業地帯に工場を持つ企業に対するあなたの個人的意見についてお尋ねします。 **Please indicate your level of agreement with the following statements concerning your personal opinion towards the government and industrial companies.**						
OT1	**以下の組織や機関について、それらが重要な決定を下すときはいつでも、私のような人々を気にかけていると信じている。** ***Whenever this organisation makes an important decision, I believe it is concerned about people like me.***						
i	政府機関 *Government institutions*						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
ii	工業地帯に工場を持つ企業 *Industrial companies.*						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
OT2	**以下の組織や機関は、それら自身が実行するといったことを達成する能力を持っていると信じている。** ***I believe this organisation has the ability to accomplish what it says it will do.***						
i	政府機関 *Government institutions*						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
ii	工業地帯に工場を持つ企業 *Industrial companies*						

	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
OT3	**以下の組織や機関はこの問題に関する約束を守ってくれるものと、私は信頼している。** ***I believe this organisation can be relied upon to keep their promises regarding this problem.***						
i	政府機関 *Government institutions*						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
ii	工業地帯に工場を持つ企業 *Industrial companies*						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
CM1	**以下の組織や機関は私のような人々の意見に正統性を見出すと思う。** ***I think this organisation finds the opinions of people like me legitimate.***						
i	政府機関 *Government institutions*						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
ii	工業地帯に工場を持つ企 *Industrial companies*						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
CM2	**以下の組織や機関は、私のような人々の意見に耳を傾けてくれる。** ***This organisation really listens to what people like me have to say.***						
i	政府機関 *Government institutions*						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
ii	工業地帯に工場を持つ企業 *Industrial companies*						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
CM3	**以下の組織や機関は、私のような人々が意思決定に十分に参加できるようにしてくれる。** ***The management of this organisation allows people like me to participate enough in decisions.***						
i	政府機関 *Government institutions*						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree
ii	工業地帯に工場を持つ企業 *Industrial companies*						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree

	STATEMENT						
	これより、いくつかの陰謀説についてお尋ねします。 **Please indicate your level of agreement with the following statements concerning conspiracy theories.**						
CS1	**地方自治体や化学企業は、[大阪湾沿岸の工業地帯/東灘区]の潜在的な化学事故の影響に関する現在の状況を市民に隠していると思う。** ***I think local governments and chemical companies are hiding from citizens the real situation concerning the consequences from potential chemical accidents [in the industrial area of Osaka Bay / Higashinada].***						
	1 全くそう思わない Strongly Disagree	2 そう思わない Disagree	3 あまりそう思わない Somewhat Disagree	4 どちらともいえない Neither Agree nor Disagree	5 ややそう思う Somewhat Agree	6 そう思う Agree	7 とてもそう思う Strongly Agree

	最後にあなた自身についてお尋ねします。お答えできるもののみ、お答えください。 GENERAL QUESTIONS						
D1	**あなたの性別は何ですか。*What is your gender?***						
	女性 Female				男性 Male		
D2	**年齢はおいくつですか。*What is your age?***						
	19 歳以下 or younger	20-29	30-39	40-49	50-59	60-74	75 歳以上 or older
D3	**あなたの最終学歴は以下のどれですか。*What is your level of education?***						
	小学校 Elementary School	高校 High School	職業、技術学校 Vocational / Technical School	学士号 Bachelor Degree	修士号 Master Degree	博士号 PhD	
D4	**あなたの世帯の年間収入はいくらですか。*What is your annual household income?***						
	Below ¥3,000,000 以下		¥3,000,001 – ¥6,000,000			Over ¥6,000,001 以上	
D5	**どの区・町に住んでおられますか。（例　東灘区徳井町/堺区出島町/高石市羽衣）** ***Which ward (ku) and town district (chō/machi) do you reside in? (example: Tokui-cho, Higashinada-ku/Dejima-cho, Sakai-ku/ Takaishi-shi, Hagoromo)***						
	区				町		
D6	**あなたの国籍は何ですか。*What is your nationality?***						
D7	**ご家庭には何人の人が住んでいますか。*How many people live in this household?***						
	1	2	3	4	5	6	7 以上 or more
D8	**ご家庭にお子様はご一緒に住んでいますか。*Are there any children living in this household?***						
	はい Yes				いいえ No		
D9	**あなたの結婚歴は以下のどれにあたりますか。*What is your marital status?***						
	シングル（結婚したことがありません） Single (never married)		結婚している、婚約者がいる、結婚状態にある Married, or in a domestic partnership	結婚しているが、別居している Married, and living separately		離婚した Divorced	死別した Widowed

アンケートはこれで終わりです。ご協力ありがとうございました。

This is the end of the questionnaire. Thank you for your cooperation.

A.3 Sample Questionnaire in S. Korea

잠재적 화학사고에 대한 의견을 묻는 설문조사

바쁘신 와중에도 본 설문조사에 참여해 주셔서 진심으로 감사드립니다. 본 설문조사는 한국의 대규모 지진, 쓰나미 또는 태풍으로 인하여 발생한 원자력 발전소, 정유공장 등 에서의 화학적 사고 (이하, 나테크 사고)와 관련하여, 그에 대한 위험 정보 공유의 필요성에 대한 일반 시민의 인식을 조사하는데 목적이 있습니다. 본 조사는,의 산업단지에서 발생가능한 나테크 사고의 위험정보공개와 관련하여, 시민의 참여를 통한 의사소통 활동에 초점을 두고 있습니다.

본 설문조사는 4 가지 항목으로 구성되어 있고, 각 항목별로 관련 설명이 제시됩니다. 이에 따라 기재되어 있는 선택지에서 가장 동의하시는 내용을 선택하여 주시면 됩니다. 귀하의 의견만을 여쭙는 설문조사이므로, 모든 설문문항에 대한 정답 또는 오답은 없습니다. 따라서, 솔직하게 귀하의 의견 그대로 답변해 주시기를 부탁드립니다.

본 설문조사는 약 25 분 정도가 소요될 것입니다. 응답해 주신 모든 내용은 통계화되어 학술적 목적으로만 사용될 것입니다. 귀하의 모든 응답은 자발적인 참여로 이루어지며, 원치 않으실 경우 설문 도중 응답을 멈추셔도 됩니다. 해당 설문 내용 및 개인 정보는 [통계법] 제 33 조(비밀보호)에 의거하여 익명성과 기밀성이 유지됩니다. 응답해 주신 귀하의 의견은 소중한 연구 자료로써 활용될 것입니다.

또한, 본 설문조사 또는 해당 프로젝트와 관련하여 문의 사항이 있으신 경우, 아래로 연락주시기 바랍니다.

- 조사담당자: 쥬오지오스 디미트리오스 (Tzioutzios Dimitrios)
- 이메일: dimitrios.tzioutzios.33x@st.kyoto-u.ac.jp
- 연락처: +81-80-8045-7412

다시 한 번 설문에 참여해 주셔서 대단히 감사드립니다.

Opinion Questionnaire for Potential Chemical Accidents

Thank you very much for taking some of your time to participate in this study, despite your busy schedule. The objective of this research project is to assess the perception of the general public concerning the disclosure of risk information about chemical accidents caused by a severe typhoon large earthquake and / or tsunami in S. Korea. These types of accidents are called Natech accidents. The particular focus of this survey is the communicative action people engage in with regards to the disclosure of information about potential Natech accidents at industrial parks near urban areas.

Please indicate your level of agreement with each statement by selecting the appropriate option from the scale provided below each statement. Please answer as honestly as possible. Since this is an opinion questionnaire, there are no correct or incorrect answers. Your cooperation is highly appreciated.

This survey will take about 25 minutes. Please note that your responses are voluntary, anonymous and completely confidential. The data collected will be presented in an aggregated form and published only for academic purposes. Of course, if you think that you do not want to answer such questions, there is no need to forcibly answer.

If you would like to learn more or discuss about this project you may contact the principal investigator Mr. Tzioutzios Dimitrios at the following e-mail address: dimitrios.tzioutzios.33x@st.kyoto-u.ac.jp or telephone number: +81-080-8045-7412.

Thank you once again for your participation.

	STATEMENT
	다음은 자연재해(지진, 해일, 태풍 등)로 인하여 발생 가능한 화학사고에 대한 인식에 관한 질문입니다. **아래의 각 문항에서 귀하의 의견과 가장 가까운 응답에 표시하여 주시기 바랍니다.** **Please indicate your level of agreement with the statements concerning potential chemical accidents caused by natural disasters (for example large earthquakes, tsunami or typhoons).**
NT1	**나는 자연재해로 인하여 발생 가능한 화학사고가 중요한 문제라고 생각한다.** ***I consider potential chemical accidents caused by natural disasters an important problem.***
	1 매우 그렇지 않다 Strongly Disagree / 2 그렇지 않다 Disagree / 3 별로 그렇지 않다 Somewhat Disagree / 4 보통이다 Neither Agree nor Disagree / 5 약간 그렇다 Somewhat Agree / 6 그렇다 Agree / 7 매우 그렇다 Strongly Agree
NT2	**나는 자연재해가 인근 산업단지에 화학사고를 유발할 가능성이 있다는 것이 우려된다.** ***I am concerned about natural disasters causing potential chemical accidents at the nearby industrial park.***
	1 매우 그렇지 않다 Strongly Disagree / 2 그렇지 않다 Disagree / 3 별로 그렇지 않다 Somewhat Disagree / 4 보통이다 Neither Agree nor Disagree / 5 약간 그렇다 Somewhat Agree / 6 그렇다 Agree / 7 매우 그렇다 Strongly Agree
NT3	**만약 극심한 태풍이 발생할 경우, 화학사고가 내가 거주하는 지역의 산업단지에 발생할 수 있다고 생각한다.** ***If a severe typhoon occurs, I think that a chemical accident could happen at the industrial park in my city.***
	1 매우 그렇지 않다 Strongly Disagree / 2 그렇지 않다 Disagree / 3 별로 그렇지 않다 Somewhat Disagree / 4 보통이다 Neither Agree nor Disagree / 5 약간 그렇다 Somewhat Agree / 6 그렇다 Agree / 7 매우 그렇다 Strongly Agree
NT4	**만약 극심한 태풍이 인근 산업단지에 화학사고를 유발한다면, 그 지역 주민들이 직접적으로 영향을 받을 수 있다고 생각한다.** ***If a severe typhoon causes a chemical accident at the nearby industrial park, I believe the residents could be directly impacted.***
	1 매우 그렇지 않다 Strongly Disagree / 2 그렇지 않다 Disagree / 3 별로 그렇지 않다 Somewhat Disagree / 4 보통이다 Neither Agree nor Disagree / 5 약간 그렇다 Somewhat Agree / 6 그렇다 Agree / 7 매우 그렇다 Strongly Agree
NT5	**나는 인근 산업단지에 화학사고가 발생하는 동안 어떻게 대응해야 하는지 알고 있다.** ***I believe I know how to respond during a chemical accident at the nearby industrial park.***
	1 매우 그렇지 않다 Strongly Disagree / 2 그렇지 않다 Disagree / 3 별로 그렇지 않다 Somewhat Disagree / 4 보통이다 Neither Agree nor Disagree / 5 약간 그렇다 Somewhat Agree / 6 그렇다 Agree / 7 매우 그렇다 Strongly Agree

	STATEMENT						
	다음 문제에 대하여 귀하의 의견과 가장 가까운 응답에 표시하여 주시기 바랍니다. **문제: 내가 거주하는 지역의 산업단지에 발생 가능한 화학사고에 관한 공개적으로 이용할 수 있는 정보가 부족하다.** Problem description: **There is a lack of publicly available information about potential chemical accidents at the industrial park in my city.**						
PR1	**나는 이것이 중요한 문제라고 생각한다.** ***I think this is an important problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
PR2	**정부 기관들은 이 문제를 해결하기 위한 조치를 취해야 한다.** ***Government institutions should take action to solve this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
PR3	**이 문제와 관련하여, 나아가야 할 방향과 현실 사이에 큰 차이가 있다고 생각한다.** ***Concerning this problem, I think there is a large gap between the way things should be and the way they are now.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IR1	**이 문제는 나에게 심각한 영향들을 미칠 수 있다.** ***This problem could have serious consequences for me.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IR2	**이 문제는 나의 일상생활에 어떠한 변화를 가져올 수 있다.** ***This problem could make a difference in my daily life.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IR3	**내 자신은 이 문제와 강한 연관이 있다.** ***There is a strong relationship between myself and this problem.***						

	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
CR1	**나는 이 문제에 관한 상황을 내가 개선할 수 있다고 생각한다.** ***I believe I can improve the situation regarding this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
CR2	**나는 이 문제에 관하여 내가 무언가를 하는 것을 막는 장애물들이 거의 없다고 생각한다.** ***I believe there are few obstacles preventing me from doing something about this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
CR3	**나의 의견은 이 문제에 관하여 일을 하고 있는 정부 관계자들에게 중요하다.** ***My opinions matter to those in the government, who are working on this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
KSN1	**만약 한 지역 주민이 발생 가능한 화학사고에 관한 정보를 요청했다면, 그것은 다른 주민들에게 불편함(불쾌감)을 줄 수 있다.** ***It could cause discomfort to other citizens, if a local resident asked for information concerning the potential for chemical accidents.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
KSN2	**발생 가능한 화학사고에 관한 의사결정에 일반 시민들은 참여할 수 없다고 생각한다.** ***It is not expected that citizens participate in decisions regarding the potential for chemical accidents.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
KSN3	**나는 정부가 발생 가능한 화학사고에 관한 정보를 공개하는 방식을 신뢰한다.** ***I trust the way the government handles access to information about potential chemical accidents.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree

OC1	**만약 발생 가능한 화학사고에 따른영향에 관한 정보가 공개된다면, 산업단지 인근에 위치한 지역의 토지가격이 하락할 것이다.** ***Land prices would likely drop in areas near the industrial park, if information about the potential consequences of chemical accidents was made available.***

	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree

OC2	**만약 발생 가능한 화학사고에 따른 영향에 관한 정보가 공개된다면, 지역경제 (예: 관광, 상업)에 영향을 미칠 것이다.** ***The local economy (for example tourism, trade) would be affected, if information about the consequences of potential chemical accidents was made available.***

	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree

OC3	**발생 가능한 화학사고와 관련한 최신 정보에 대한 접근의 부족은, 시민들이 이 문제를 이해하는 것을 어렵게 한다.** ***Lack of access to updated information about potential chemical accidents, limits citizens' understanding of the problem.***

	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree

OC4/ CS5	**나는 지방정부 및 화학 회사들이 발생 가능한 화학사고의 잠재적인 영향에 대한 실제 정보를 해당 지역의 주민들에게 공개하지 않는다고 생각한다.** ***I think local governments and chemical companies are hiding from citizens the real situation concerning the consequences from potential chemical accidents at the nearby industrial area.***

	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree

OC5	**지역주민들이 발생 가능한 화학사고와 관련한 정보가 공개되는 것을 원하지 않는 것에 대하여 어떤 이유가 있다고 생각하십니까? 만약 그렇다면, 그 이유를 기입해 주세요.** ***Are there any other reasons why local residents do <u>NOT</u> want information about potential chemical accidents to become available? If yes, please describe.***

RC1	**나는 이 문제에 대하여 어떻게 대처해야 하는지 분명하게 알고 있다.** ***I have a clear idea about how to deal with this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
RC2	**나는 이 문제에 대하여 정부가 어떻게 접근해야 하는지 알고 있다.** ***I have an idea about how the government should approach this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
RC3	**나는 국내의 다른 지역에서 화학사고와 관련한 위험정보의 공개에 대한 모범사례가 있다고 생각한다.** ***I believe there are examples from other regions of the country on how to deal with this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
CR4	**나는 이 문제에 대해서 내가 무언가를 할 수 있다고 생각한다.** ***I believe I can do something about this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
SM1	**나는 이 문제에 대해서 관심이 있다.** ***I am curious about this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
SM2	**나는 이 문제에 대해서 자주 생각한다.** ***I frequently think about this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
SM3	**나는 이 문제에 대해서 보다 더 잘 이해하고 싶다.** ***I want to better understand this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IFrf1	**나는 이 문제에 대해서 알기 위하여 많은 시간과 노력을 투자하였다.** ***I have invested a lot of time and energy learning about this problem.***						

	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IFrf2	**나는 이 문제에 관한 정보의 질을 판단할 수 있다.** ***I am capable of judging information quality about this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IFrf3	**나는 이 문제와 관련된 최신 정보를 확인하기 위한 신뢰할 만한 정보원을 가지고 있다.** ***I have a selection of trusted sources that I check for updates concerning this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IPrm1	**나는 이 문제와 관련한 모든 의견에 관심이 있다.** ***I am interested in all views concerning this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IPrm2	**나는 여러 정보원을 통하여 이 문제에 대하여 알고 싶다.** ***I want to know about this problem from multiple sources.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IPrm3	**나는 이 문제에 관하여 반대의 의견들도 듣는다.** ***I listen even to opposite views regarding this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IFwd1	**나는 이 문제에 관하여 나의 가족과 친구들에게 알려주려고 노력하고 있다.** ***I am trying to inform my family and friends about this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IFwd2	**나는 이 문제에 대한 나의 의견들에 확신을 가지고 자주표현한다.** ***I frequently express my opinions confidently about this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree

IFwd3	**나는 이 문제 해결에 관하여 다른 사람들을 설득하는 데 어느 정도 시간을 투자할 가치가 있다고 생각한다.** ***I believe it is worth spending some time to persuade others about solving this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IShr1	**만약 누군가 나에게 이 문제에 대하여 물어본다면, 나는 이 문제에 대하여 그 사람에게 답변해줄 의향이 있다.** ***I am willing to talk to someone about this problem, if they ask me.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IShr2	**만약 누군가가 나에게 이 문제에 대하여 물어본다면, 나는 그 사람이 원하는 어떠한 정보라도 공유할 의향이 있다.** ***If someone asks me about this problem, I am willing to share any information they want.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IShr3	**누군가가 이 문제에 관한 화제를 제기하면, 나는 그토론에 참여하고 싶다.** ***I like to participate in the discussion about this problem, when others bring up the topic.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
ISek1	**나는 이 문제에 관하여 인터넷, 신문, 휴대전화의 어플리케이션 등을 통하여 적극적으로 정보를 찾아본다.** ***I actively search for information on the Internet, in newspapers, via mobile applications or otherwise, regarding this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
ISek2	**나는 이 문제에 관하여 새로운 정보가 있는지 주기적으로 확인한다.** ***I regularly check to see if there is new information about this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree

ISek3	**나는 사람들에게 이 문제와 관련한 정보를 요청한다.** ***I ask people for information related to this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IAtt1	**나는 신문, 웹사이트 또는 소셜 미디어를 통하여 기사들을 찾을 때, 이 문제와 관련한 기사를 읽는다.** ***I read about topics related to this problem, when I find articles in newspapers, websites or social media.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IAtt2	**만약 누군가가 이 문제에 대하여 이야기한다면, 나는 그 사람이 하는 말을 주의 깊게 듣는다.** ***If someone talks about this problem, I listen carefully to what they have to say.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
IAtt3	**나는 이 문제에 관한 뉴스 보도에 주의를 기울인다.** ***I pay attention to news reports regarding this problem.***						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree

	STATEMENT						
	다음은 1) 정부기관, 2) 산업단지 내의 화학회사에 대한 귀하의 개인적인 의견을 묻는 질문입니다. **아래의 각 문항에 대한 응답 항목 중 귀하의 생각과 가장 일치하는 것을 선택하여 주시기 바랍니다.** **Please indicate your level of agreement with the following statements concerning your personal opinion towards the government and chemical industrial companies.**						
OT1	**이하의 조직이 중요한 결정을 내릴 때마다, 나와 같은 일반 사람들을 고려한다고 생각한다.** ***Whenever this organisation makes an important decision, I believe it is concerned about people like me.***						
i	*정부기관 Government institutions*						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
ii	*화학 회사 Chemical industrial companies*						

	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
OT2	**나는 이하의 조직이 그들의 목표를 달성할 수 있는 능력이 있다고 생각한다.** ***I believe this organisation has the ability to accomplish what it says it will do.***						
i	*정부기관 Government institutions*						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
ii	*화학회사 Chemical industrial companies*						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
OT3	**나는 이하의 조직이 문제에 관한그들의 약속을 지킬 수 있다고 믿는다.** ***I believe this organisation can be relied upon to keep their promises regarding this problem.***						
i	*정부기관 Government institutions*						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
ii	*화학회사 Chemical industrial companies*						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
CM1	**나는 이하의 조직이 나와 같은 일반 사람들의 의견을 타당한 것으로 여긴다고 생각한다.** ***I think this organisation finds the opinions of people like me legitimate.***						
i	*정부기관 Government institutions*						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
ii	*화학회사 Chemical industrial companies*						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
CM2	**이하의 조직은 나와 같은 일반 사람들의 의견에 귀를 기울여 준다.** ***This organisation really listens to what people like me have to say.***						
i	*정부기관 Government institutions*						

	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
ii	*화학회사 Chemical industrial companies*						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
CM3	**이하의 조직의 경영자 (또는 관리자)는 나와 같은 일반 사람들이 의사결정에 충분히 참여할 수 있도록 기회를 제공한다.** ***The management of this organisation allows people like me to participate enough in decisions.***						
i	*정부기관 Government institutions*						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree
ii	*화학회사 Chemical industrial companies*						
	1 매우 그렇지 않다 Strongly Disagree	2 그렇지 않다 Disagree	3 별로 그렇지 않다 Somewhat Disagree	4 보통이다 Neither Agree nor Disagree	5 약간 그렇다 Somewhat Agree	6 그렇다 Agree	7 매우 그렇다 Strongly Agree

	마지막으로 귀하에 대한 질문들입니다. 응답 가능한 질문에 답변 부탁드립니다. **GENERAL QUESTIONS**						
D1	**귀하의 성별은 무엇입니까?** ***What is your gender?***						
	여자 Female				남자 Male		
D2	**귀하의 연령은 어떻게 되십니까?** ***What is your age?***						
	19 세 이하 or younger	20-29	30-39	40-49	50-59	60-74	75 세 이상 or older
D3	**귀하의 최종 학력은 어떻게 되십니까?** ***What is your level of education?***						
	초등학교 Elementary School	고등학교 High School	기술학교 Vocational / Technical School	대학교 Bachelor Degree	대학원 (석사) Master Degree	대학원 (박사) PhD	
D4	**귀하의 가족 전원의 연간 소득은 다음 중 어디에 해당됩니까?** ***What is your annual household income?***						
	Below ₩20,000,000 원이하		₩20,000,001 원이상 – ₩40,000,000 원미만			Over ₩40,000,001 원이상	

D5	**귀하가 현재 살고 계시는 행정구역은 어떻게 되십니까? (예: 구, 동)** ***Which ward (ku) and town district (chō/machi) do you reside in? (example: Deoksin-ri, Onsan-eup, Ulju-gun, Ulsan)***
구	동
D6	**귀하의 국적은 어떻게 되십니까?** ***What is your nationality?***
D7	**귀하의 가정에는 귀하를 포함하여 현재 모두 몇 분의 가족이 같이 살고 있습니까?** ***How many people live in this household?***
1 2 3 4 5 6 7 이상 or more	
D8	**귀하의 가정에는 자녀가 있습니까?** ***Are there any children living in this household?***
네 Yes	아니오 No
D9	**귀하의 결혼 상태는 어떻습니까?** ***What is your marital status?***
미혼 Single (never married)	결혼 Married
이혼 Divorced	사별 Widowed

이것으로 설문을 마칩니다. 협력해 주셔서 대단히 감사합니다.

This is the end of the questionnaire. Thank you for your cooperation.

A.4 Sample Pre-game Questionnaire for Game Evaluation

NATECH RISK PERCEPTION

	STATEMENT						
	Please indicate your level of agreement with the statements concerning potential chemical accidents caused by natural hazards (for example large earthquakes or tsunami).						
1	***I consider potential chemical accidents caused by natural hazards (for example the Fukushima Dai-ichi Nuclear Powerplant accident) a serious problem.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
2	***I am concerned about chemical accidents caused by natural hazards and their consequences.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
3	***If a large earthquake happens, I think that a chemical accident could occur at an industrial park in Osaka Bay.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
4	***If a large earthquake happens, I think that a chemical accident could occur at an industrial facility near to where I live/work.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
5	***If a large earthquake causes a chemical accident at an industrial facility, I believe the nearby residents could be directly impacted.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
6	***I believe I know how to stay safe if a chemical accident at an industrial facility happens near to where I live/work.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree

COMMUNICATIVE BEHAVIOUR TOWARDS NATECH RISK COMMUNICATION

	STATEMENT						
PR1	***I think chemical accidents caused by natural hazards are an important problem.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
PR2	***Government institutions should take action to address chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree

PR3	***Concerning chemical accidents caused by natural hazards, I think there is a large gap between the way things should be and the way they are now.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IR1	***Chemical accidents caused by natural hazards could have serious consequences for me.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IR2	***Chemical accidents caused by natural hazards could make a difference in my daily life.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IR3	***There is a strong relationship between myself and the problem of chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
CR1	***I believe I can improve the situation regarding chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
CR2	***I believe I can do something about chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
CR3	***My opinions matter to those in the government, who are working on managing chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
RC1	***I have a clear idea about how to deal with chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
RC2	***I have an idea about how the government should approach chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
RC3	***I have an example in mind on how to deal with chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
SM1	***I am curious about chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
SM2	***I think about chemical accidents caused by natural hazards frequently.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
SM3	***I want to better understand chemical accidents caused by natural hazards.***						

	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IFrf1	***I have invested a lot of time and energy learning about chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IFrf2	***I am capable of judging information quality about chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IFrf3	***I have a selection of trusted sources that I check for updates concerning chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IPrm1	***I am interested in all views concerning chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IPrm2	***I want to know about chemical accidents caused by natural hazards from multiple sources.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IPrm3	***I listen even to opposite views regarding chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IFwd1	***I am trying to inform my family and friends about chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IFwd2	***I frequently express my opinions confidently about chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IFwd 3	***I believe it is worth spending some time to persuade others about the problem of chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IShr1	***I am willing to talk to someone about chemical accidents caused by natural hazards, if they ask me.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IShr2	***If someone asks me about chemical accidents caused by natural hazards, I am willing to share any information they want.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IShr3	***I like to participate in discussions about chemical accidents caused by natural hazards, when others bring up the topic.***						

	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
ISek1	***I actively search for information on the Internet, in newspapers, via mobile applications or otherwise, regarding chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
ISek2	***I regularly check to see if there is new information about potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
ISek3	***I ask people for information related to chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IAtt1	***I read about topics related to chemical accidents caused by natural hazards, when I find articles in newspapers, websites or social media.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IAtt2	***If someone talks about chemical accidents caused by natural hazards, I listen carefully to what they have to say.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IAtt3	***I pay attention to news reports regarding chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree

RISK AWARENESS

	STATEMENT						
	Please indicate your level of agreement with the statements concerning potential chemical accidents caused by natural hazards (for example large earthquakes or tsunami).						
1	***The hazard intensity influences the potential consequences.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
2	***All areas are potentially exposed to the same hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
3	***Avoiding hazards plays a significant role when choosing a house.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
4	***Spatial planning and resource allocation matter in reducing the impacts of potential chemical accidents caused by natural hazards.***						

	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
5	***Access to chemical information affects residents' preparedness actions.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree

IMPORTANCE OF RISK COMMUNICATION

	STATEMENT						
	Please indicate how important the following types of information are for you.						
1	***Information on hazardous chemical substances and their adverse health effects.***						
	1 Not Important at All	2 Slightly Important	3 Somewhat Important	4 Moderately Important	5 Important	6 Very Important	7 Extremely Important
2	***Information on areas potentially affected by chemical accidents caused by natural hazards.***						
	1 Not Important at All	2 Slightly Important	3 Somewhat Important	4 Moderately Important	5 Important	6 Very Important	7 Extremely Important
3	***Instructions and/or training on preparedness and response actions for chemical accidents caused by natural hazards.***						
	1 Not Important at All	2 Slightly Important	3 Somewhat Important	4 Moderately Important	5 Important	6 Very Important	7 Extremely Important
4	***Information on available evacuation shelters in case of a chemical accidents caused by a natural hazard.***						
	1 Not Important at All	2 Slightly Important	3 Somewhat Important	4 Moderately Important	5 Important	6 Very Important	7 Extremely Important
5	***Information on existing plans and preparedness measures taken by the government and industries for potential chemical accidents caused by natural hazards.***						
	1 Not Important at All	2 Slightly Important	3 Somewhat Important	4 Moderately Important	5 Important	6 Very Important	7 Extremely Important

EXPECTATIONS FROM THE GAME

	STATEMENT						
	Please indicate your level of agreement with the statements concerning your attitude and expectations about serious gaming.						
1	***I enjoy playing analog games, like board, card or tabletop games.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
2	***I learn through playing games.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
3	***I expect I will enjoy the game.***						

	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
4	***I expect to do well and achieve a high score in the game.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
5	***I expect to learn much from the game.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
6	***I think the use of serious games in education is generally valuable.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree

	GENERAL QUESTIONS						
1	***Please write here a 4-digit numeric code of your choice (e.g., 6714 or 5532). <u>Please save this code</u>*** *as you will be asked to input it again in the post-game questionnaire.*						
2	***How often do you play analog games, like board, card or tabletop games?***						
	Never	A couple of times per year		Monthly		Weekly	Daily
3	***What is your gender?***						
		Female				Male	
4	***What is your age?***						
	19 or younger	20-29	30-39	40-49	50-59	60-74	75 or older
5	***What is your level of education?***						
	Elementary School	High School	Vocational / Technical School		Bachelor Degree	Master Degree	PhD
6	***What is your nationality?***						
7	***What is your marital status?***						
	Single (never married)		Married			Divorced	Widowed

This is the end of the questionnaire. Thank you for your cooperation.

A.5 Sample Post-game Questionnaire for Game Evaluation

NATECH RISK PERCEPTION

	STATEMENT						
	Please indicate your level of agreement with the statements concerning potential chemical accidents caused by natural hazards (for example large earthquakes or tsunami).						
1	***After the game, I consider potential chemical accidents caused by natural hazards (for example Fukushima Dai-ichi Nuclear Powerplant accident) a serious problem.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
2	***After the game, I am concerned about chemical accidents caused by natural hazards and their consequences.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
3	***After the game, if a large earthquake happens, I think that a chemical accident could occur at an industrial park in Osaka Bay.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
4	***After the game, I think that, if a large earthquake happens, a chemical accident could occur at an industrial facility near to where I live/work.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
5	***After the game, I believe, if a large earthquake causes a chemical accident at an industrial facility the nearby residents could be directly impacted.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
6	***After the game, I believe I know how to stay safe if a chemical accident at an industrial facility happens near to where I live/work.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree

COMMUNICATIVE BEHAVIOUR TOWARDS NATECH RISK COMMUNICATION

	STATEMENT						
PR1	***After the game, I think potential chemical accidents are an important problem.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
PR2	***After the game, I believe government institutions should take action to address potential chemical accidents.***						

	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
PR3	***After the game, concerning potential chemical accidents, I think there is a large gap between the way things should be and the way they are now.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IR1	***After the game, I think potential chemical accidents could have serious consequences for me.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IR2	***After the game, I think potential chemical accidents could make a difference in my daily life.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IR3	***After the game, I think there is a strong relationship between myself and the problem of potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
CR1	***After the game, I believe I can improve the situation regarding potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
CR2	***After the game, I believe I can do something about potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
CR3	***After the game, I think my opinions matter to those in the government, who are working on managing potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
RC1	***After the game, I will have a clear idea about how to deal with potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
RC2	***After the game, I will have an idea about how the government should approach potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
RC3	***After the game, I will have an example in mind on how to deal with potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
SM1	***After the game, I will be curious about potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
SM2	***After the game, I will think about potential chemical accidents frequently.***						

	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
SM3	***After the game, I want to better understand potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IFrf1	***After the game, I will invest a lot of time and energy learning about potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IFrf2	***After the game, I feel capable of judging information quality about potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IFrf3	***After the game, I will search for a selection of trusted sources that I can check for updates concerning potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IPrm1	***After the game, I am interested in all views concerning potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IPrm2	***After the game, I want to know about potential chemical accidents from multiple sources.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IPrm3	***After the game, I will listen even to opposite views regarding potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IFwd1	***After the game, I will try to inform my family and friends about potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IFwd2	***After the game, I will frequently express my opinions confidently about potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IFwd 3	***After the game, I believe it will be worth spending some time to persuade others about the problem of potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IShr1	***After the game, I will be willing to talk to someone about potential chemical accidents, if they ask me.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IShr2	***After the game, if someone asks me about potential chemical accidents, I will be willing to share any information they want.***						

	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IShr3	***After the game, I would like to participate in discussions about potential chemical accidents, when others bring up the topic.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
ISek1	***After the game, I will actively search for information on the Internet, in newspapers, via mobile applications or otherwise, regarding potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
ISek2	***After the game, I will regularly check to see if there is new information about potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
ISek3	***After the game, I will ask people for information related to potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IAtt1	***After the game, I will read about topics related to potential chemical accidents, when I find articles in newspapers, websites or social media.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IAtt2	***After the game, if someone talks about potential chemical accidents, I will listen carefully to what they have to say.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
IAtt3	***After the game, I will pay attention to news reports regarding potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree

RISK AWARENESS

	STATEMENT						
	Please indicate your level of agreement with the statements concerning potential chemical accidents caused by natural hazards (for example large earthquakes or tsunami).						
1	***The hazard intensity influences the potential consequences.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
2	***All areas are potentially exposed to the same hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree

3	***Avoiding hazards plays a significant role when choosing a house.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
4	***Spatial planning and resource allocation matter in reducing the impacts of potential chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
5	***Access to chemical information affects residents' preparedness actions.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree

IMPORTANCE OF RISK COMMUNICATION

	STATEMENT						
	Please indicate how important the following types of information are for you.						
1	***Information on hazardous chemical substances and their adverse health effects.***						
	1 Not Important at All	2 Slightly Important	3 Somewhat Important	4 Moderately Important	5 Important	6 Very Important	7 Extremely Important
2	***Information on areas potentially affected by chemical accidents.***						
	1 Not Important at All	2 Slightly Important	3 Somewhat Important	4 Moderately Important	5 Important	6 Very Important	7 Extremely Important
3	***Instructions and/or training on preparedness and response actions for chemical accidents.***						
	1 Not Important at All	2 Slightly Important	3 Somewhat Important	4 Moderately Important	5 Important	6 Very Important	7 Extremely Important
4	***Information on available evacuation shelters in case of a chemical accident.***						
	1 Not Important at All	2 Slightly Important	3 Somewhat Important	4 Moderately Important	5 Important	6 Very Important	7 Extremely Important
5	***Information on existing plans and preparedness measures taken by the government and industries for potential accidents.***						
	1 Not Important at All	2 Slightly Important	3 Somewhat Important	4 Moderately Important	5 Important	6 Very Important	7 Extremely Important

EDUCATIONAL GAME ASSESSMENT

	STATEMENT						
1	***I enjoyed playing the game.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
2	***I found the game fun.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree

3	***I found the game challenging.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
4	***During the game I lost track of time.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
5	***I found the game to be realistic.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
6	***I found the game overall easy to understand.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
7	***I found the length of the game (i.e., how much time it took) appropriate.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
8	***I found the information provided during the game sufficient.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
9	***I learned a lot from the game.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
10	***The game motivated me to learn more about disaster preparedness for chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
11	***The game motivated me to learn more about disaster preparedness for chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
12	***The game changed how I think about disaster preparedness for chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
13	***The game changed how I think about disaster preparedness for chemical accidents caused by natural hazards.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
14	***The game is useful in generating discussions about disaster preparedness for chemical accidents.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
15	***The game is useful in generating discussions about disaster preparedness for chemical accidents caused by natural hazards.***						

	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
16	***The game is a meaningful educational tool.***						
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree

	GENERAL QUESTIONS
1	***Please write here the same 4-digit numeric code you wrote in the pre-game questionnaire.***
2	***If some aspect of the game especially appealed to you, what is it?***
3	***If some aspect of the game needs improvement, what is it?***

This is the end of the questionnaire. Thank you for your cooperation.