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High Impact/ Low Frequency extreme events: Enabling Reflection and Resilience in a Hyper-connected World

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Abstract

Helbing (2013:51) poignantly argues that 'Globalization and technological revolutions are changing our planet'. Along with the benefits and opportunities associated with worldwide collaboration networks comes 'pathways along which dangerous and damaging events can spread rapidly and globally'. With our hyper-connected world underpinned by hyper or hybrid-risks, the impact of unexpected events such as floods, earthquakes, financial crisis, and cyber-attacks has revealed the fragility and vulnerabilities that lie within the social/technological/economic/political/ecological interdependent systems. In particular, events that affect critical infrastructure such as damage to electric power, telecommunications, transportation, health care systems, financial markets and water-supply systems can have local, regional and global impact. Taleb (2007) calls these extreme events 'Black swans' to describe their inherent quality of surprise. Many of the systemic risks that characterize Natural Hazard triggered Technological disasters (NATECH) often arise from unanticipated consequences of interactions within and between different types of systems. Johnson and Tivnan (2012:65) argue that, '…understanding, controlling and predicting extreme behavior [of NATECH] is an important strategic goal to support resilience planning'. In this light, a new paradigm is required to support disaster risk reduction (DRR) embedded in hyper-risks; one that will develop not only anticipatory measures for risk management but also prepare for the unpredictable and the 'unknown' by building organisational resilience for hyper-risks in general and NATECH disasters in particular. In this paper we explore the emergency management domain associated with the Fukushima Daiichi nuclear accident to show the hyper-connectivity and hyper-risks that permeated the problem space and thereby show how 'reflective responses' underpinned by 'critical reflective practices' can be used to support resilience in such a complex disaster.

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1. Introduction

1.1. Network Mindset and hyper-risks

Recent disasters such as Hurricane Katrina (2005), Fukushima Daiichi nuclear accident (2011), Hurricane Sandy (2012), and Typhoon Haiyan (2013) highlight the vulnerability of communities to environmental and human-made disasters and the crippling effect that such disasters can have on the social and economic well-being of a nation. Such disasters have shown how such vulnerabilities reside in the complex interdependencies across different infrastructures (electric power, telecommunications, transportation, healthcare and water-supply systems) and the social costs that emerge from disruption of these interconnected systems. This is cogently explained by Vespignani (2010:984) when he said 'relatively localized damage in one system may lead to failure in another, triggering a disruptive avalanche of cascading and escalating failures. Understanding the fragility induced by multiple interdependencies is one of the major challenges in the design of resilient infrastructures'. Such systemic failures emerge from the interconnectivity that characterizes the 'network space'. Network thinking or more clearly a 'network mindset' (Vespignani, 2009) is essential for understanding the network structure, network behavior and the feedback/feedforward effects resident within these systems. What emerges from the study of networks is the insightful requirement to evaluate actions and behaviours not in isolation but recognizing that cause and effect are complex and nonlinear (Masys, 2014). The 'networked' understanding of hyper-risks (Helbing, 2013) requires a more holistic approach to hazard identification and risk management that transcends the linear agent-consequence analysis. With events such as the 2010 Ash Cloud stemming from the eruption of Eyjafjallajökull and the resulting disruptions to air travel and trade in Europe (Harris et al, 2010), we see how 'networked risks' are not confined to national borders or a single sector, and do not fit the monocausal model of risk. As argued by Renn, Klinke and van Asselt (2011:234) such risks or hyper-risks are '...complex (multi-causal) and surrounded by uncertainty and/or ambiguity'. The risk landscape thereby calls for 'reflective response' one that is based on 'critical reflective practices' to support better understanding of interdependent systems and thereby contribute to enabling organizational resilience. A 'resilient organization' is understood as a 'learning organization' which does not unravel in 'predictable' and 'unpredictable' disasters. A resilient organization is realised only when the 'communities of practice' are supported and nurtured as part of the overall goal of resilience. Such an organization will also be in a better position to respond and mitigate disaster risks both internally as well as externally for the 'at risk' community.

Scope for hyper-risks in an inter-connected world: The case for NATECH

United Nation's International Strategy for Disaster Reduction (UNISDR) (2009) defines 'risk' as 'the combination of the probability of an event and its negative consequences'. In the context of this paper this definition is extended to define hyper-risks as not only 'an event' but also processes that trigger an event or series of unpredictable events with a likelihood of trans-border cascading effect.

Hyper-risks are hybrid because 'a number of basic features that may have often been regarded as mutually exclusive' (Beck, 2009) by the dominant risk, crisis and disaster theories are inclusive and fused. Hyper or hybrid-risks are connected to several systems such as the society, environment, organization and the like (Helbing, 2013). In contrast, the dominant risk framework compartmentalises risks and hazards into three types: natural, social and technological (Jones and Hood, 1996; Beck, 1992). These are useful analytical distinctions. But in the context of hyper-risks they overlap and intersect to produce hybrid hazards known as quasi-natural hazards or NATECH hazards (Jones and Hood, 1996; David, et al., 2007). As a result, the conventional distinction between these three types of hazards has come under serious challenge from the disaster sociologists and geographers in light of recent disasters such as the Hurricane Katrina (David et al., 2007) and the Tohuku Earthquake.

A new paradigm is required to support DRR embedded in hyper-risks; one that will develop not only anticipatory measures for risk management; but also prepare for the unpredictable and the 'unknown' by building organizational resilience (Wildavsky, 1988; quoted in Jones and Hood, 1996; Taleb, 2007) for hyper-risks in general and NATECH disasters in particular. This merits the question, how can we build organizational resilience to comprehend hyper-risks such as conjoined environmental and NATECH disasters. There are several ways to promote organizational resilience. This paper, proposes a 'reflective response' one that is based on 'critical reflective practices' and systems thinking. The discussion on reflective response is resumed after describing 'what are NATECHs' in the ensuing section.

What are NATECHs?

NATECHs occur at the seams of natural, environmental and technological hazards. It is the conjoint natural/technological disaster that makes the NATECH situation so different and complex (Cruz and Krausmann, 2008) as it challenges risk management and risk governance. In this hyper-connected world, the NATECHs emerge as the reification of these hyper-risks. Although awareness of the need to better address NATECH risk has been on the rise (see Cruz, 2012), gaps remain across the board in terms of collective awareness as shown by the lack of NATECH risk governance internationally or organizationally. The consequences of these conjoint events are much more substantial for communities than those posed by each hazard alone. This paper therefore moves from the traditional concept of crisis and disaster management to one of complexity management that can respond adequately to the conjoint NATECH disaster. What emerges from the analysis of the NATECH case studies/literature regarding gaps (see Steinberg, Sengul and Cruz, 2008; Cruz and Okada, 2008; Krausmann and Mushtaq, 2008; Krausmann and Cruz, 2013; Cruz, 2012; Ozunu et al., 2011) is how critical reflective practices can be harnessed to support preparedness and emergency planning through mindfulness in order to understand NATECHs and mitigate their consequences.

1.2. The perspective of 'reflective response' in an inter-connected world

In 2005, the Hyogo Framework for Action (2005-2015) urged the DRR community to shift from a reactive to proactive disaster response. In order to promote organizational resilience, against the odds of environmental and NATECH disasters, 'reflective response' is proposed. Reflective response is not a stand-alone response it is rather complementary to reactive and proactive disaster responses. At the outset, 'reflective response' is defined as a combination of individual, organized and critical reflections and reflective strategies embedded in an organization's context.

Individual reflection is self-reflective (Friere, 1972) and resonates with the concept of 'sense making' in organizations (Weick, 1995) that requires 'interpretation' (Weick, 1995:13). Interpretation is influenced by people's belief and mental models. According to Weick (1995:15), sense making has a 'strong reflexive quality' to the process of interpretation because 'people make sense of things by seeing a world on which they already imposed what they believe'. In this dynamic and complex risk landscape reflective practices thereby can help to avoid overconfidence through a generative learning approach. Individual reflection is also being a 'reflective practitioner' (Schön, 1983) that involves: 'on-the-spot surfacing, criticizing, restructuring, and testing of intuitive understanding of experienced phenomena; often it takes the form of a reflective conversation with the situation' (Schön, 1983:241-242). More concretely, Schön (1983) made the distinction between 'reflection-in-action' and 'reflection-on-action', in order to reframe and solve some breakdown in the smooth running of experience (Plager, 1994; Schön, 1983). Reflection-in-action is based on a rapid interpretation of the situation, whereas 'reflection-on-action' occurs after the event to improve future action (Ghaye and Ghaye, 1998; Schön, 1983). Individual reflection is also about a balance between the right side of the brain (that is concerned with creativity, imagination, perception, intuition, synthesis, wonder and spirit) and the more dominant left side of the brain (that is concerned with qualities of the mind associated with analysis, reason, rationality and logic) (Johns, 2009). According to Johns reflection is then a balanced approach which requires a shift in thinking and new ways of responding.

On the other hand, organized reflection is 'less about the individual reflective practitioner and more about organizing reflection' (Reynolds and Vince, 2004:1) and in doing so, it takes account of 'social and political processes at work in the organization of reflection'. This resonates with the comprehensive approach supporting complexity management in the defence, security and safety domains (Masys, 2014). Organizational theorists argued that 'reflection' did not fully capture the critical perspective of reflection in the context of organization and management studies (Antonacopoulou, 2004; Kayes, 2004; Nicolini et al., 2004; Reynolds and Vince, 2004; Welsh and Dehler, 2004). According to them reflection has to go beyond the individual to draw lessons from the power relations (Kemmis, 1985) within and between communities of practice in order to advance professions and management practices (Welsh and Dehler, 2004). The emphasis is then 'placed […] on creating collective and organizationally focused processes for reflection' (Reynolds and Vince, 2004:11). Organizing reflection is also linked closely to developing strategies for organizational development (see Antonacopoulou, 2004; Kayes, 2004; Nicolini et al., 2004; Reynolds and Vince, 2004; Welsh and Dehler, 2004).

Lastly, 'Critical thinking' is analogous to critical reflection. 'Critical thinking is a complex process of deliberation which involves wide range of skills and attitudes […] to think in critically analytical and evaluative ways [means] using mental process such as attention, categorisation, selection and judgement' (Cottrell, 2005:1-2). The frameworks of 'organizational learning' and 'learning organizations' are central to critical reflection (Gould, 2004). Organizational learning is learning that takes place at an organizational level and as a result gains new knowledge (Argyris and Schön, 1996; quoted in Fook, 2004). The framework of a 'learning organization', on the other hand, engages with systemic thinking, teamwork and work based learning of a practitioner/s within the wider organizational context (Senge, 1990; Gould, 2004). In a learning organization 'people are continually discovering how they create their reality. And how they can change it' (Senge, 1990: 13) being a part of the world rather than a separate entity.

In light of the above, reflective response is then a 'dynamic developmental process' (Bolton, 2005:5) that occurs at the interface of individual, collective and critical levels that can be applied to support complexity management. It encompasses interrogating the assumptions integrated into the analysis along with reflecting on the 'norms' and 'appreciations' which underpin judgments and actions (Reynolds and Vince, 2004).

2. Case study: The triple disasters in Japan

On 11 March 2011 Japan was hit by yet another devastating earthquake named the Great East Japan aka Tohoku. The Tohoku earthquake triggered a giant tsunami that reached the height of 40.5 meters in the city of Miyako and killed more than 15,844 people, and destroyed many businesses, livelihoods and homes. The tsunami also sparked nuclear accidents including the meltdown of three nuclear reactors in the Fukushima Daiichi Nuclear Power Plant. The destruction of the Fukushima Daiichi nuclear power plant resulted in massive radioactive contamination of the Japanese mainland. As described in Wang et al (2013:127) `the nuclear accident at Fukushima Daiichi NPP has had significant impact on nearby communities due to radioactive contamination of land and groundwater, and long-term evacuation of people from their homes, farms, businesses and communities`. The hyper-risks associated with this NATECH resulted in radioactive caesium entering the ecosystem, and becoming ubiquitous, contaminating water, soil, plants and animals. It has been detected in a large range of Japanese foodstuffs, including spinach, tea leaves, milk, beef, and freshwater fish up to 200 miles from Fukushima (Starr, 2013). Estimates of the total economic loss range from US$250-$500 billion and the displacement of over 150,000 people. For the global nuclear industry, the accident has led to 'regulatory changes that may slow or even eliminate plans for expansions of and investment in nuclear power in many countries' (Cruz, 2012) thereby affecting the global energy market with geopolitical implications.

3. Discussion

A close scrutiny through the lens of reflective response reveals the caveat of the Fukushima case. Most importantly, the dominant reactive and pro-active disaster responses reveal their inadequacies to comprehend as well

as prepare for NATECH disasters. The DIET Report Executive summary (2013:9) argues that although the earthquake and tsunami of March 11 2011 are considered triggers of the cataclysmic event, `the subsequent accident at the Fukushima Daiichi Nuclear Power Plant cannot be regarded as a natural disaster. It was a profoundly manmade disaster – that could and should have been foreseen and prevented'. In support of this, the analysis conducted by Krausmann and Cruz (2013:823) highlight '…model uncertainties reflected in insufficient design and low levels of preparedness, overconfidence in existing safety measures, cost/benefit considerations, complacency or the violation of safety regulations as key factors that contributed to the disaster`. The hyper-risks (hybrid risks) and the resident pathogens (Reason, 1997) rooted in a dysfunctional mindset that permeated the `network space` of the Fukushima case study highlights the necessity for a reflective analysis of the interdependencies and the potential for cascading effects described in (Helbing, 2013; Krausmann and Cruz, 2013:823).This mindset described in the Executive Summary of the Final Report- Investigation Committee on the Accident at Fukushima Nuclear Power Stations of Tokyo Electric Power Company (2012:32) reified as '...as a lack of a sense of *urgency and imagination toward a major tsunami'*.

In terms of the accident, lack of imagination and urgency translate as a lack of foresight informed action. Fukushima nuclear accident can thereby be considered as `…not a natural disaster but clearly man-made` (DIET, 2013:12). The failure of imagination is a stark reminder of the findings of The 9/11 Commission Report (2004:336) that articulated '...a failure of imagination and a mindset that dismissed possibilities' as a key underlying factor. The mindset that reified as a lack of imagination and inaction is rooted in the mental models regarded as incorporating ones biases, values, learning, experiences and beliefs about how the world works. In this way, such mental models reified as a mindset of organizational impediments to safety.

As noted in the DIET (2013: 2) report, 'the accident was the result of Tokyo Electric Power Company's (TEPCO) failure in preparing against earthquakes and tsunamis, despite repeated warnings about the potential for such catastrophes. Although TEPCO had reviewed possible countermeasures for the kind of events that subsequently transpired, it postponed putting any measures into place for the other events, using the scientific improbability of such events as an excuse'. This mindset that failed to recognize and act upon warning and signals (vulnerabilities) highlight an 'organizational impediment` likened to a `resident pathogen`(Reason, 1997) seeded years before that permeated the network space and shaped decision making at all levels. The prevalence of this organizational impediment is reflected in the DIET (2013:10) noting that the Fukushima Daiichi NPP was ` … incapable of withstanding an earthquake and tsunami. Tokyo Electric Power Company (TEPCO) as the nuclear operator, the Nuclear Safety Commission (NSC) and the Nuclear and Industrial Safety Agency (NISA) as the regulatory authorities, and the Ministry of Economy, Trade and Industry (METI), as the government body promoting nuclear power, all failed to correctly prepare and implement the most basic safety requirements, such as assessments of the probability of damage by earthquakes and tsunamis, countermeasures toward preparing for a severe accident caused by natural disasters, and safety measures for the public in case of a large release of radiation'. The primary purpose of existing laws and regulations was seen to be for the promotion of the use of nuclear energy and not for public safety and health (DIET, 2013:17). The values and beliefs of TEPCO, NSC and NISA characterized the hyper-risks (hybrid risks) in the form of organizational mindset that shaped decision making. In this sense, the hybrid risks created a complex network structure and behaviour that unravelled with the trigger of the tsunami resulting in a cascade-like event revealing the lack of preparation, insufficient vulnerability analysis and response. Weick and Sutcliffe (2007:2) highlight how such an event can be '...considered as an abrupt and brutal audit: at a moment's notice, everything that was left unprepared becomes a complex problem, and every weakness comes rushing to the forefront'.

Assumptions shaped the mindset that negated foresight and anticipation. DIET Report (2013: 44) revealed:

> 'Underlying NISA's views was the conviction that, with regard to nuclear emergency preparedness, it was not necessary to anticipate an accident that would release enough radioactive material as to actually require protective actions, since (they believed) rigorous nuclear safety regulations, including safety inspections and operation management, were in place in Japan.

Contributing to the organizational impediments was the lack of organizational learning. As described in the DIET (2013:i3) 'Japan has itself dealt with a number of nuclear power plant accidents, small and large. Most of these were responded to, but without sufficient transparency; sometimes they were concealed by the organizations concerned... while maintaining that accidents could not occur in Japan'. What was foreseeable was not actioned leaving Japan unprepared for this accident. This reluctance to embrace organizational learning is reflected in the '... lack of commitment for reviewing laws and regulations, in diligent reflection of accident responses and safeguarding measures in other countries. Without the diligent reflection the industry focused on the promotion of nuclear energy but not public safety and health' (DIET, 2013:17). The hyper-risks then interconnected the political, technological, social, ecological and economic domains. The organizational impediments rooted in a mindset that focused on promoting nuclear energy instead of health and safety reified as 'hardwired politics' (Masys, 2010). Unreflective practices perpetuated this mindset. The unintended consequence was the erosion of preparedness and a dysfunctional mindset that dismissed possibilities.

3.1 Translating reflective responses into practise

Systems thinking (Senge, 1990), characterized by seeing wholes and interconnections is critical to understanding complex disaster aetiology associated with NATECHs. As described in Masys (2010), the systems lens can enable decision makers to see beyond events and detect underlying patterns as well as the forces and causal relationships that hold these patterns in place. Van der Merwe (2008: 220) argues that '...a systems worldview, together with tools and techniques to make structure visible, is important for building quality scenarios'. Scenario planning, as a reflective practice has been shown to support the challenge of mental models (Chermack and Nimon, 2013: 815). The nuclear emergency preparedness system of Fukushima Prefecture was not based on the assumption that a nuclear disaster, earthquake and tsunami could occur simultaneously. This resulted in the prefecture facing insurmountable difficulties in establishing an initial response structure when the event occurred. To challenge the resident mindset within the nuclear industry in Japan required mindful exploration of disaster scenarios. Foresight and imagination that recognizes the inherent interdependencies in such a complex hyper-risk landscape support understanding of the vulnerabilities, triggers and consequences thereby influencing decision making. Reflective practice of scenario thinking can support the challenges of mental models. In the context of scenario planning, the major purposes of changing mental models can be seen as opening up perceptions, transitioning toward a learning organization, and as a result, decisions can encompass a wider range of thought (Chermack and Nimon, 2013:819).

Reflective practice at the organizational level then allows members to '…critically evaluate their own thinking, but also, to investigate the shared, collective assumptions and expectations, as well as the institutionalized rules and routines' (Hilden and Tikkamaki, 2013). Within the context of DRR and NATECH, this provides a methodology to address many of the gaps identified regarding the hyper-risks. Reflective practices that support mindfulness affords organizations involved in DRR within the context of NATECH a 'heightened awareness in critical and complex situations which require novel responses' (Zundel, 2012). As described in Weick and Sutcliffe (2007), mindfulness (as a an offshoot of reflective practice) supports a preoccupation with failure and a reluctance to simplify interpretations, coupled with sensitivity to weak signals and the ability to respond locally and in real time. In this sense, reflection is about engaging in analysis, considering alternatives, seeing things from various perspectives to better understand the NATECH hyper-risks and potentially cascading effects. As noted from the Fukushima case study and the studies on NATECH accidents conducted by Cruz (2012) and Krausmann and Cruz (2013), the requirement to test and challenge assumptions, theories and ideas emerges as a key enabler to support DRR.

The increasing complexity of today's interconnected and interdependent systems as it pertains to DRR has resulted in calls for greater understanding and development mechanisms for coping with uncertainty and shocks to the system. Strategic reflection creates an opportunity to share, compare and explore mental models thus opening up consideration of the variety of possibilities. Enabling resilience therefore requires a constant sense of unease that prevents complacency, as argued by Hollnagel and Woods (2006). In supporting resilience, the ability to learn and change requires the application of double-loop learning. This learning is rooted in an organizations ability to frame and then reframe, or to change the way in which they think about or view a concept or idea (Senge, 1990). Chermack and Nimon (2013:816) argue that 'most critical is the ability to change ones' mental model in order to

view the future of an organization through a new lens. Such reflective practice requires dialogue and conversation about strategic issues decision makers are facing (Chermack, 2011; Georgantzas and Acar, 1995; Schwartz, 1991; van der Heijden, 1997, 2005; Wack, 1985a)', a reflective capacity that was not apparent in the Fukushima case study.

4. Conclusion

The root cause of the accident was human-made stemming from interconnected hyper-risks characterized as a mental model that focused on benefits to the nuclear industry over health and safety and resulted in a mindset that lacked imagination and action. They minimized the possibility of accidents to the point of denying it, and in doing so they lost their humility in the face of reality. To tackle such hyper-risks, which has such global impact, this paper has argued for developing organizational resilience by adopting 'reflective response'. Reflective response is understood as a combination of individual, collective and critical reflections and reflective strategies to build the capacity of learning organizations. Building organizational resilience is seminal in this hyper-connected world whereby the social, technological, political, ecological and economic domains are entangled. The case study also demonstrated the importance of adopting non-linear, complex mental models in order to prepare for the NATECH disasters embedded in hyper-risks. Currently, the dominant risk, crisis and disaster theories and practices are inadequate to offer a space to comprehend the true nature of hyper-risks and NATECH disasters.

Reflective practices such as systems thinking and scenario planning increases the richness of thinking and facilitates insightful dialogues that challenge the linear mindset. Such reflective practice can be used to investigate the peripheral, the weak signals, to explore the possibility space of the risk landscape thereby establishing a focus on evolving goals and strategic priorities of stakeholders and how these support resilience. It is well documented in the literature that NATECH awareness and preparedness levels both by the industry and authorities is low. Therefore, existing preparedness and response plans need to be improved to explicitly include the aspect of possible hazardous-materials releases, fires and/or explosions due to natural hazards to reduce the NATECH risk (Krausmann and Cruz, 2013:823). The reflective practice of foresight and scenario planning helps to uncover the complexities associated with hyper-risks by exploring the space of possibilities through critical reflection and imagination.

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