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Title: Interpreting Auckland's volcanic governance through an institutional lens

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Abstract

This paper presents critical reflections on the governance of natural hazards, in the context of New Zealand's Auckland Volcanic Field (AVF). The AVF is unusual given that there is an urban area built on this active field, and the potential for a volcanic eruption is clearly identified as a natural hazard. The occurrence of another volcanic event on the AVF seems certain. The timing of the next event remains, however, enigmatic. The problem in terms of governance of a natural volcanic hazard in Auckland is a matter not of 'if', but 'when'. Using the AVF as a case study, we place existing governance structures within a New Institutional Economics framework and, in turn, critique the role of key institutional actors across time, using O.E. Williamson's (1998) four levels of institutional analysis. In particular, we note the key challenge of incorporating time into AVF governance and socio-economic planning. Overall, this paper provides a theoretical framework for evaluating disaster recovery, in this case taking the existing legal and institutional framework of volcanic risk governance in Auckland, to assist the practical management of a low-probability, but potentially high impact natural hazard.

Keywords

Auckland Volcanic Field, Timeframes, Polycentric governance, Time in economics

1. Introduction

Auckland is the largest city in New Zealand, located on the North Island. One and a half million people live in the region, which is just over one third of New Zealand's total population. It is unusual for a city to be built on an active volcanic field. 'Active' presupposes another eruption on the field, yet the probability of this happening in our lifetime is slim, or happening in any particular year miniscule (Bebbington and Cronin 2011). The timing between volcanic events can be longer than human lifespans and generations, and therefore perceptions of risk may be misguided. The Auckland Volcanic Field (AVF) is approximately a quarter of a million years old, with an estimated lifespan of one million years.

A potential volcanic hazard has been clearly identified in Auckland (Edbrooke et al. 2003; Sherburn et al. 2007), given the current understanding of the timing of past volcanic events, the characteristics of the underlying mantle (Ashenden et al. 2011), the (geologically) recent eruption of Rangitoto island 550 years ago, along with the concentration of people living on the AVF. Governance of this volcanic hazard becomes problematic given uncertain timeframes. Consideration of extended timeframes, beyond the immediate demands of the 'present' time, involves strategic planning processes. Our ability to plan in the short term, through economic markets, government funding and election cycles is established. However, governance in the long term, incorporating geological timeframes is more problematic, given that levels of uncertainty increase, alongside an inter-temporal bias toward current or near-future generations. There is an unwillingness or lack of mandate to make intergenerational trade-offs, hampered by disagreement over the nature and extent of obligations placed on current generations towards future generations, as well as on ascertaining what the needs and preferences of future generations would be. Glavovic et al. (2010) argue that the reconciliation of "short-term, narrow interests with longer-term community interests is an underlying challenge for those advocating hazard risk reduction, sustainability and community resilience in New Zealand". Clearly, time poses analytical challenges for governance and socio-economic planning in managing volcanic risk.

The issue of timeframes and sequencing when considering volcanic events requires a great deal more scientific investigation within the economics discipline than it currently receives. Presently there is no coherent treatment of time within mainstream economics in this regard, a vacuity that is becoming more apparent. In some respects, time is treated as a pseudo commodity or resource, as evidenced in the phrases to 'buy time' or 'spend time'. The valuation of time is at the core of labour theory of value within production processes, and in business cycles time is the opportunity cost of money, particularly evident with just-in-time practices in efficient markets. Time is also treated as a mechanism for discounting (preferences of future generations) and managing risk in insurance markets. Discounted utility within neoclassical economics incorporates impatience in economic decisions, valuing present enjoyment more than future enjoyment, or realising that there is a tendency toward small payoffs now, over large payoffs later. In economic models time is treated as a linear variable that enables a system to change from one state to another. Time has been described as being "what keeps everything from happening at once" (Cummings 1922). Economic models are often criticised for not necessarily sequencing events – equilibrium is assumed at indeterminate times or some point in the future. After natural hazards, resilience is supposed to enable people to return to a form of 'normal' or pre-event situation, yet the length of time this takes is not always acknowledged or specified.

In this paper we explore how time and phasing can be better incorporated into economic models to improve the governance of volcanic risk in Auckland, when the timescales are extensive. Using extensive timeframes within economic frameworks adds complexity to the analysis, but it also allows for a more dynamic conceptualisation of governance. How time is conceptualised has a profound impact on the resulting institutions and governance structures. Government agencies are mandated to manage the risk of a volcanic event, and therefore have to confront governance in uncertain and extended timeframes.

A case study methodology is used within this paper. Case studies, or 'analytical narratives' (Alston, 2008) are appropriate for developing general theories of institutional change, and in this study are of particular importance, given that the treatment of time within economic theories is a focus. Alston (1996) notes that the case study approach is often the only way to further our knowledge about institutional change – or governance through time - and that it enables an analysis of both the determinants and consequences of institutions. This

paper uses a single-case design, populating Williamson's (1998) framework (consisting of four levels of institutional analysis), with data gathered from various sources pertaining to the governance of Auckland's volcanic risk. Data for the case study was collected in 2013 from planning documentation, archival records and secondary published data sources, direct observation, and participant observation in planning processes and risk governance. This methodological approach enables a holistic exploration of governance of volcanic risk, and an exploration of its treatment in different timeframes. The use of case studies for analysing institutions is discussed by Beckmann and Padmanabhan (2009), recognising that other emergent techniques may be appropriate given Williamson's four levels of social analysis. However, the overarching query explored in this paper, of the treatment of time within economic models and the subsequent relevance to governance is more suited to an illustrative case study approach.

This paper is organised as follows. Section 2 provides background geophysical detail on the Auckland Volcanic Field. Section 3 discusses time and economic governance, introducing Williamson's (1998) temporal classification of institutions, which enables differentiation of governance structures across timeframes. It is Williamson's theoretical framework that is used to structure the case study on governance of volcanic risk in Auckland. Section 4 looks at stakeholders and actors at different institutional levels and across different timeframes. The case study leads to a discussion in Section 5 on governance and change, the unavoidable philosophical treatment of time in metaphysics, the effects or impacts of differing cultural views of time and polycentric governance through time. These are substantial issues, which have a bearing on how planning for risks of all type are governed.

2. The Auckland Volcanic Field

The AVF covers an area of approximately 30km (longitudinal) by 20km (latitudinal), centered on the Auckland isthmus and including the harbours. The AVF is monogenetic, meaning that it is characterised by scattered volcanic vents. The AVF has been active for 248,000 years, in an estimated lifespan of one million years. In that time approximately 50 vents have erupted in the field. The land area over the volcanic field is heavily populated, with over 1 million people living on areas that have a probability of a future eruption (Bebbington and Cronin 2011). A volcanic event is considered a hazard in the Auckland region, as there is a risk to life, property, critical infrastructure and the environment – in the form of lava, ash and gases should a volcanic event occur (AELG 2012). The AVF has a highly variable history, described by Cassidy and Locke (2010) as 'spasmodic' with episodes of high intensity separated by long pauses. There is evidence of 'flare-ups' or rapid sequences over periods of less than 100 years and a large tephra volume anomaly¹ associated with the most recent eruption, occurring between 550 and 600 years ago, that created Rangitoto island. Note also that Rangitoto Island erupted within historical memory of the local Maori iwi (indigenous New Zealanders).

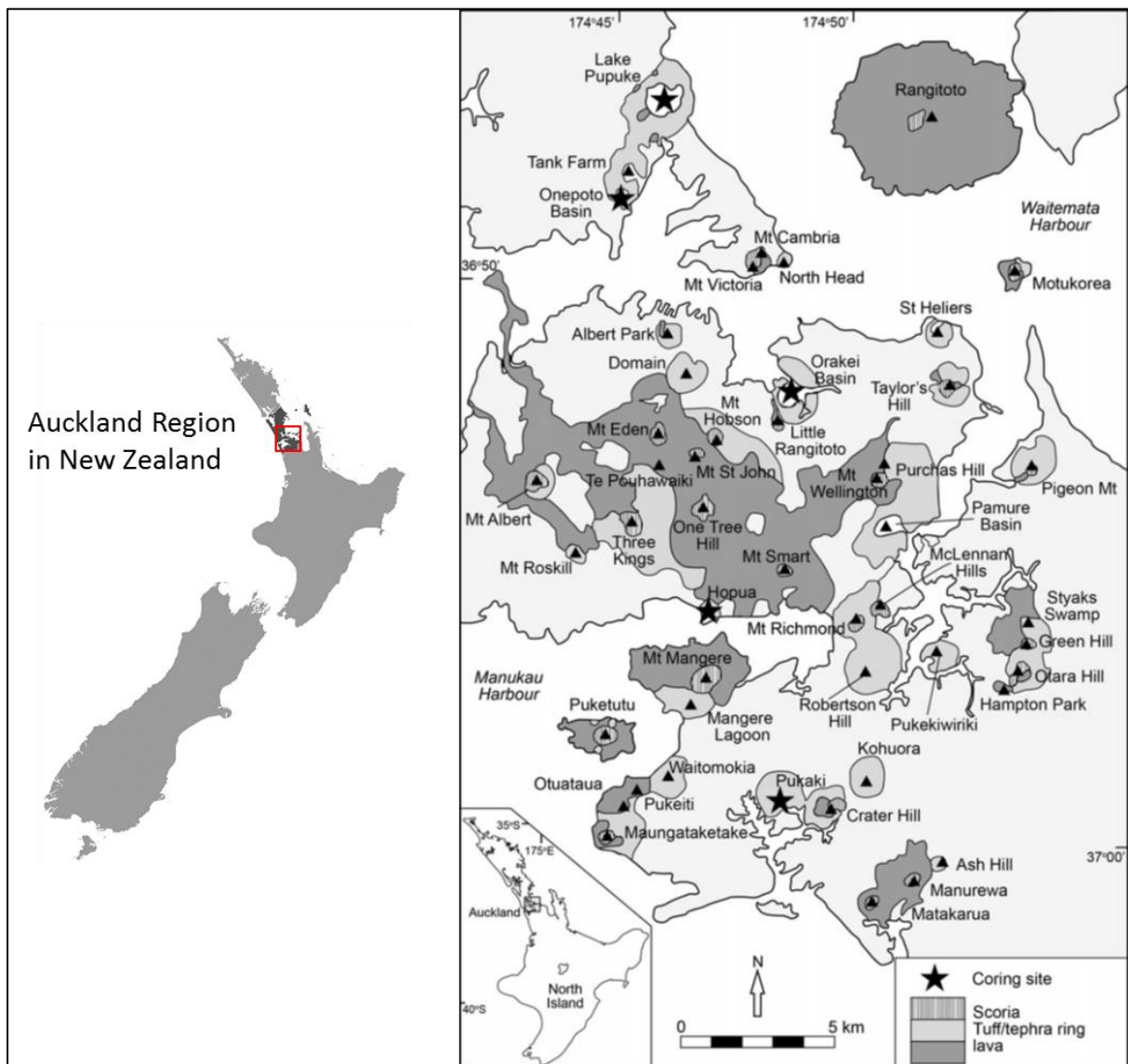
Auckland's monogenetic field shows complex structural and spatio-temporal relationships at different scales (Cassidy and Locke 2010). From the correlation of tephra layers with the eruption centres, along with the estimates for the age of each eruption, an age model was constructed by Bebbington and Cronin (2011). They found that spatial and temporal eruption recurrences in the AVF are independent of one another. There is temporal uncertainty over the next eruption, making the management of the risk challenging. There is however a strong spatial structure evident in the AVF, with a south-west to north-east direction (Fig.1).

The probability of an eruption in any given year is low, reflecting uncertainty about the timing of eruptions on the volcanic field. Planning for, and governing, volcanic risk in Auckland is necessary, and raises the issue of natural disaster governance particularly in a heavily populated urban area (Olsen and Williams 2005; Glavovic

¹ This event comprises of up to half of the field volume of tephra in this one event (Kermode et al. 1992).

et al. 2010).² It is noted that Auckland's rapid population growth and urban expansion placed pressure on local authorities to allow development in areas previously considered unsuitable due to their exposure to hazards, also including flooding or land instability (Edbrooke et al. 2003). As with other studies on the effects of natural hazards on the economy and functioning of society (Rose 2004), it is the indirect effects of a volcanic event that would impact Auckland the greatest (MCDEM 2008; AELG 2012), in terms of the cascading effects on critical infrastructure and the pivotal role that Auckland plays in the New Zealand economy.

Fig.1 The Auckland Volcanic Field



Source after Kermodé 1992

² A volcanic event in the AVF could consist not only of an eruption, but also seismic shaking and tsunamis. In this regard a volcanic event in Auckland is representative of a suite of hazards. It is worth noting that Auckland is also susceptible to additional hazards such as coastal erosion and active faulting.

3. Time and economic governance

3.1 Governance

Governance can be described as the way in which individuals and institutions exercise authority through formal and informal rules. This covers policy formulation and implementation, but also how rules and social norms determine people's actions. Governance includes the formal (Williamson 1991 and 1998) and informal (North 1991; Ostrom 2005) structures by which decisions are made, the legal rights, obligations that are present, and how they are communicated and mediated within a society and economy. Economic governance is an area of inquiry within New Institutional Economics that integrates social, behavioural, legal and political theories into economic theory. Traditionally governance, or how we govern, fell under political theories of power and decision-making. Applying the principles of governance to hazards (both natural and man-made) is an emergent field of study, which has been termed Disaster Governance (Tierney 2012).

To frame the governance of Auckland's volcanic risk over extended timeframes, Williamson's (1998) *temporal* classification of institutions is used. Governance can be concentrated in a hierarchy or dispersed between decision makers. Although this framework was formulated for economic production purposes, explaining the emerging trend toward specialisation and transactions, the principles can be extended to the governance of other situations (Ostrom 2005), and is of particular relevance to hazards. Different rule sets or different behaviour could have very divergent outcomes, with attention focusing on how individual behaviour affects economic outcomes. Williamson's (1998) seminal contribution was a *differentiation of appropriate governance structures for different timeframes*. These range from the immediacy of the here and now, when decisions are taken instantaneously, to periods of up to one thousand years, when institutions are embedded in cultural norms. As timeframes extend to the future, there is increased uncertainty about the conditions that future generations will face. This poses challenging theoretical questions and tests the limits of planning frameworks.

3.2 Governance in the distant future

Mainstream economists have generally accounted for time through discounting, as in the Cost Benefit Analysis method. Similarly game theorists have modelled economic behaviour through the use of agents in finite games. Optimal choices and decisions can be worked back from the end strategy (Dixit, Skeath and Reiley 2009). Repeated games introduce an inter-temporal trade off, discounting the present for the sake of the future. How far into the future our economic models extend depends on how the modeller constructs time. The concept of infinity poses theoretical and empirical challenges not only for mathematical modelling, but also for economic modelling. Carse (1987) introduced the notion of an infinite game, which has no discernible beginning or ending. It is played with the goal of continuing play, for the sake of continuity only. Therefore the strategies of the players will conceivably be radically different, as the aim of the game is continuity, not personal gain (Mesquita 2010).

Although this paper does not advocate the use of an infinite game in the context of volcanic governance, the geological timeframes involved force an evaluation of how far into the future current economic governance extends, and whether governance would differ if those timeframes were varied? Such questions challenge the design of appropriate governance and policy intervention. In terms of governance of volcanic risk there is radical uncertainty about when the next volcanic event will take place. Yet, a due diligent society should plan for it. Campanella (2006) argues that resilience in the face of a natural disaster is largely a function of the resourcefulness and affirmative action of people, or how the situation is governed. Indeed Clarke (2008) goes further and argues that the term 'natural disaster' is insufficiently critiqued as an apt description. There is no disaster without people and Clarke prefers the term 'institutional disaster' signifying the inability to react to (arguably) foreseen disasters.

3.3 Toward a governance timeframe

Williamson (1998) distinguishes between four levels or timeframes for analysis: periods of between 100 to 1,000 years (Level 1); intermediate timeframes between 10 to 100 years (Level 2) within which legislation or rules can change; a period of up to 10 years (Level 3) when contractual agreements between people may constrain decision making; and the continuous or spontaneous timeframe when economic exchange takes place (Level 4) (see Fig 2). Governance of Auckland's volcanic risk is discussed for each of Williamson's levels.

Governance regimes are polycentric and multi-scale, giving rise to “many centres of decision-making that are formally independent of each other” Ostrom et al. (1961:831). There is variation of governance across the hazards cycle, revealing a lack of integration and a piecemeal approach to the different types of potential hazards e.g. climate change, flooding or volcanic risk. Disaster governance is nested within and influenced by overarching societal governance systems (Ostrom 2005; Tierney 2012). The complexity of a natural hazard challenges any attempt to create institutions to manage it. However, by identifying the relevant stages of a volcanic event, the appropriate governance structures can be evaluated.

Moving from Level 1 to Level 4 implies an acceleration of the timeframes involved in social change (Fig. 2). The slowly changing levels impose constraints on the levels below them, signifying feedback in the framework. The framework is integrative by nature, thereby enabling a synthesis of competing theories which allows for the incorporation of shocks such as volcanic hazards and their destructive forces. Culture affects and influences the institutional environment, which in turn affect the governance structures and level of transaction costs. Governance shapes resource allocation and the functioning of the market. Although Williamson explicitly formulated his framework to explain economic exchange, it can be applied to any exchange, including social contracts. A social contract is the tacit agreement establishing the authority of the state over the individual. It is different across countries, depending on constitution and apparatus of the state.

The governance of a volcanic eruption requires looking at the impacts of an eruption over different time periods, given the expected sequencing of activities prior to the volcanic event, during the event and in the reconstruction phase. It is dependent on how land use planning operates, especially the treatment of risk in the planning process, formalised laws and the informal ties between individuals. It also requires a consideration of the role of the governing and mediating agencies, including the role of leadership, and the setting within which they operate.

Fig. 2 Williamson’s Economics of Institutions - Four levels of analysis

		Theory		Frequency (years)	Core Focus	Purpose (<i>in context of governing volcanic risk</i>)
Level 1	Embeddedness	Social Theory	Slow Change	100 to 1,000	Informal Institutions, Customs, Traditions and Norms	Social stability, Cultural identity, Cohesion of society and culture.
Level 2	Institutional Environment	Economics of Property Rights		10 to 100	Formal Regulation with regard to property, judiciary and bureaucracy	Establish rights and responsibilities. (<i>Spatial and urban planning</i>).
Level 3	Institutional Arrangement	Transaction Cost Economics	Continuous Change	1 to 10	Governance of contracts	Govern contracts for maximum efficiency. (<i>Can include the social contract and market based contracts such as insurance</i>).

Level 4	Resource Allocation	Neo-classical Economics / Agency Theory		Continuous	Resource allocation, Market exchange	Efficiency, profit maximization (<i>Disaster Management</i>)
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Source: Adapted from Williamson (1998)

3.3.1 Level 1 Embeddedness

Level 1, *Embeddedness*, is taken as given (exogenous) by most economists, as institutions change very slowly. At this level, the informal constraints brought about by a set of moral, ethical and behavioural norms of that particular society guide the way that society operates. These norms include how the society reacts to natural disasters, the expectations around behaviour in the face of a destructive volcanic event. These norms are shaped in New Zealand by cultural precedence, such as Maori understandings of volcanic events as passed down the generations through myth and oral history (Cashman and Cronin 2008), the scientific research and understanding of the volcanic field and how that is communicated to Auckland communities (Daly 2009), or through the challenges of informing the newer migrants to the Auckland area of knowledge of geological processes and the volcanic field. Therefore the rate of social learning and the communication of ideas, history and research determine these social norms.

3.3.2 Level 2 Institutional Environment

Level 2, *Institutional Environment*, results from the political process and in turn the legal process which underpins the rules by which economic activity is organised at any point. This level encapsulates the policy making process, judiciary and bureaucracy of government and from an institutional economic perspective, and property rights feature dominantly within the level. Property related institutions establish a bundle of rights and obligations associated with ownership and use of land, resources, buildings and all forms of property. Anderies *et al.* (2004) note that in the 1980s the ‘property rights’ solution persisted as the method of choice for solving common pool resource and socio-ecological systemic problems, with the debate at that time focused on private or governmental ownership. A property rights based approach to resource management is practiced in New Zealand, under the Resource Management Act, 1991 (Horsley 2011). The planning system faces the challenge of mitigating the effects of a known volcanic hazard on the largest urban area of New Zealand.

3.3.3 Level 3 Institutional Arrangements

Level 3, institutional arrangements, for Williamson (1998) is where transaction costs transpire, particularly through the establishment of contracts. It has been noted that the reliance on formal mechanisms, such as contracting, leads to a reliance on legal institutions, such as ceding the power to resolve disputes to the judiciary. This can lead to bureaucracy and inefficiency in economic exchange. Furthermore, this can create a transaction cost trap, and may hinder the formation of trust between individuals/stakeholders (Molm *et al.* 2000). Social contract theorists such as Hobbes, Rousseau and Rawls explain the existence of the state in terms of a contract for distributing and managing civil liberties. The over-reliance on state agencies for upholding the social contract has been identified by Bowles and Gintis (2002) who argue for the return to community governance, where appropriate. The New Zealand government does emphasise the importance of self-help and the need to organise an emergency response at a community or local level in the days immediately after an event, more aligned with Bowles and Gintis’ community governance. In the context of governing volcanic risk in New Zealand, the state plays a pivotal role in minimising personal and societal risk. This occurs on two levels, firstly in the maintenance of the social contract, particularly in directing the recovery and rebuild after a natural disaster, and secondly in the mitigation of risk through the regulation or intervention in the insurance market.

3.3.4 Level 4 Resource Allocation

Level 4, *Resource Allocation*, in Williamson’s (1998) framework equates with neo-classical market theory, where decisions are taken under presumed full-information. In the market setting efficiency is assumed, akin to Adam Smith’s invisible hand, or a ‘spontaneous order’ is present (Hayek 1944 and 1964). For Hayek the spontaneity is threatened through centralisation of decision making in an economy and herein lies the tension

between economic management or *laissez faire* market processes. This level is important for the governance of a volcanic hazard as it calls into question the strategy of either centralised or polycentric governance. In the immediate aftermath of a volcanic event or a natural hazard, there is an element of distinct individualised behaviour required for survival. This is despite the centralised processes that may come into effect – such as Marshal Law, protection of property and lock-down of vulnerable business districts. Williamson does not allocate a specific time period in this level – presumably it is for periods under one year. Increasingly economic transactions are becoming instantaneous, particularly in financial and capital markets (Johnson et al. 2012). With regard to natural disasters, a further differentiation of timeframes may be required, given that in the first days after an event, energies are focused on saving lives, treating injured people, securing basic services and eliminating immediate danger. Thereafter follows a clean-up phase, including securing any dangerous infrastructure, followed by repair and rebuilding. The latter two stages may however eventuate within Level 3.

Using these four timeframes, or levels of analysis, as means to structure a discussion of governance of a high-impact low probability event, the paper applies it to a case study of governing volcanic risk in Auckland.

4. Case Study Governance framework for volcanic risk in Auckland

This section presents the current governance structures for managing volcanic risk in Auckland. Fig. 3 shows the actors and jurisdiction of Auckland's volcanic risk governance. Different sets of rules and expected behaviour operate on different timescales. The actors are divided into government agencies, civil society organisations, private or market agents and hybrid organisations, highlighting the different jurisdictions and their remits. Auckland's governance structures for a volcanic event are matched to Williamson's (1998) governance levels, which are placed on a timescale, characterised by institutional 'lock-in' or the time required to change that set of rules. It must be remembered that volcanic risk is one in a portfolio of potential hazards and risks, managed by these agencies and individuals (AELG 2012).

Fig. 3 Auckland’s Volcanic Risk Governance – Actors, their Jurisdiction and Governance level (timeframe)

	Actors	Capacity in Volcanic governance	Governance level
Governmental Agencies	Department of Prime Minister and Cabinet	Overall governmental direction and coordination. Ability to manage the response to natural disaster e.g. establishing the Canterbury Earthquake Recovery Bill 2011.	Level 3 and Level 4 (under emergency)
	Ministry of Civil Defence and Emergency Management (within the Department of Internal Affairs)	Operates under Civil Defence Emergency Management Act (CDEMA) 2002, and is run as a business unit of the Department of Internal Affairs. Has the ability to issue a state of emergency, either over the entire country (as first invoked in February 2011, after the Christchurch earthquake) or within a specific location/region for a localised event.	Level 2 and Level 4
	Civil Defence Emergency Management Groups	Mandated under CDEMA 2002, including coordination with emergency services such as Police, Fire Service, Paramedics. Each group maintains operational staff from local authorities, emergency services and lifeline utilities.	Level 3 and Level 4
	Ministry for the Environment	Guides the strategic direction of planning throughout the country, (largely under the Resource Management Act (RMA) (1991), including volcanic hazard planning through the RMA.	Level 2 and Level 3
	Parliamentary Commissioner for the Environment	Overall governance of environmental administration from the Environment Act 1986.	Level 2 and Level 3
	Earthquake Commission (EQC)	Crown entity, established under the Earthquake Commission Act 1993. Provide natural disaster insurance for residential property and administer the natural disaster fund, including managing investment and reinsurance.	Level 2 and Level 3
	Department of Building and Housing	Operates under the Building Act 2004 which aims to ensure the safety and integrity of buildings. Potential to reduce risk to buildings through design requirements in the Building Code.	Level 2
	Local Government NZ	Operates under the Local Government Act (LGA) 2002 amongst other legislation that relates to local government (notably the RMA, 1991). Acts as the collective body for regional councils and local authorities. Forum for coordinating concerted action/policies.	Level 3
	Auckland Council	Identifying hazards through resource consent and planning processes, as required by the Resource Management Act (RMA) 1991 and CDEMA (2002). Undertakes risk assessment and preparing risk mitigation plans; providing information and early warnings on hazards; Planning emergency responses. <i>RMA 1991, CDEMA 2002, LGA 2002, Building Act 2004, LGOIMA 1987, Forest and Rural Fires Act 1977.</i>	Level 3 and Level 4
Civil Society	Community Groups and NGOs	Spontaneous organisation, outside of formal agencies/channels. Can include churches, residents groups, interest groups	Level 4 (ability for continuous change)
	Individuals	Mandated through the emergency response campaign – ‘Get Ready Get Thru’ from the Civil Defence. Importance of networks and social capital.	Level 4
	Ratepayers/citizens	Contribute to overall planning through Long Term Planning.	Level 3
	Iwi	Principles of Kaitiakitanga (guardianship), Tuku (gift giving or reciprocity), and Rahui (restriction) guide action. Some of these principles are within the Treaty of Waitangi. Social norms and indigenous knowledge of natural environment.	Level 1 and Level 4
Private/Market Agents	Land and Business Developers	Decisions to locate/invest in a volcanic area.	Level 2
	Small and medium enterprises	Can play a significant role in recovery and reconstruction, given the structure of the New Zealand economy with many small to medium sized businesses. Preparedness for a volcanic activity, including contingency planning for least business disruption, provisions for business continuity after an event.	Level 2
	Insurance industry	Will affect the build or rebuild of buildings after a volcanic event, or in light of other natural hazards in New Zealand.	Level 2 and Level 3
Hybrid Organisations	Auckland Engineering Lifelines Group	Established by the Auckland Regional Council in 1996 and is a partnership of approx. 40 organisations comprising local government, utilities and other interest groups. Aim to reduce vulnerability of Auckland’s lifelines to hazard events and ensure service reinstatement after a disaster.	Level 2 and Level 3
	Universities and Research Agencies	Information provision, synthesis and integration of research findings into policy processes.	Level 2 and Level 3

Source: Adapted from Glavovic et al. (2010) based on Williamson’s (1998) governance levels

4.1 Governance Actors

4.1.1 Government Agencies

Central government agencies play a significant role in terms of setting the legal structures and guiding the planning framework of the country, and operate predominantly in Levels 2 and 3. The New Zealand Prime Minister can set the direction of recovery through allocation of financial resources or political guidance, while the Minister of Civil Defence has powers to evoke a state of emergency after a natural hazard occurs. Regional and local government agencies are major players in the management of natural disasters from planning provisions for dealing with an event, to coordination and resourcing the practical response to an event. In the immediate aftermath of a natural disaster, there is often military style control over the affected area, where government agencies take control over resources (Pilling 2012). At such times ‘normal’ rules do not apply. The Department of Prime Minister and Cabinet and the Ministry of Civil Defence and Emergency Management operate at Level 4, in the period immediately following a natural hazard. Typically this would result in a type of social contract between the government and citizens of the affected area, with the intention of supporting recovery. As natural disasters affecting heavily populated urban areas happen so infrequently, there is limited past experience of coordinating the response in the immediacy period at Level 4, although some Civil Defence and Emergency Management exercises have been undertaken in New Zealand. Exercise Ruaumoko in 2008 was a natural disaster exercise to role-play and test the nation’s preparedness for a volcanic eruption in Auckland (MCDEM 2008).

Civil defence and emergency management has been described as a three-tiered structure in New Zealand, comprising of national, regional and local council authority (Doyle et al. 2011), through a cooperative governance approach.

In New Zealand, five main Acts (laws) affecting natural hazards planning have been identified (Glavovic et al. 2010): Resource Management Act 1991, Local Government Act 2002, Civil Defence and Emergency Management Act 2002, Building Act 2004, Local Government Official Information Management Act 1987. The role played by state planning agencies predominantly occurs at Level 3, which relate to the governance of contracts in the short term. Examples include regional policy statements, regional plans and district plans, under the Resource Management Act. Certain laws operate in longer timeframes, but typically a ‘long-term’ plan such as the Auckland Plan, introduced in 2012, has only a 20-30 year outlook, rather than up to 100 years or beyond. Spatial planning is only short-to-medium term (10-20 years), largely serving the needs of the current generation, rather than considering the demands of future generations.

Glavovic et al. (2010) critique the management of natural risk in general through the planning process in New Zealand and note that the public typically prioritises issues of immediate impact and direct impact rather than taking steps to reduce hazard risks. Not all New Zealand communities discount hazard risks and prioritise more immediate concerns. Maori operate with the customary principle of *Kaitiakitanga* or guardianship – but in general, the area of statutory planning for the long term (Levels 1 and 2) is challenging from an ethical, philosophical and practical perspective (Carse 1987). There is no specific land use planning provision in place to restrict land use or development with respect to volcanic hazards in Auckland (Becker et al. 2010a and 2010b). They argue that hazard avoidance through land use planning is not feasible given the population size, and extent of economic and urban development. The exact location of future eruptive activity cannot be pinpointed until magma rises close to the surface during an event. All of these factors make implementing rigid land use planning rules that prevent exposure to volcanic processes virtually impossible.

4.1.2 Civil Society

Civil society has a crucial role to play in the governance of a volcanic event. The Civil Defence and Emergency Management Act aims to build community resilience through an all-hazards approach that is based on a ‘Reduction, Readiness, Response and Recovery’ (the ‘4Rs’) emergency management approach (MCDEM 2005). This, in essence, devolves responsibility to civil society, in partnership with government agencies, while depending on volunteers who provide support for the community when required. A ‘*Get Ready Get Thru*’ campaign’ exists in

New Zealand, which places significant responsibility on the individual and household to prepare for an emergency. Information campaigns can guide the desired response from individuals, but in the face of a disaster, people act according to what the situation requires. This can be positive through communities working together, as evidenced in the behaviour that transpired following the Canterbury earthquake series in 2010/2011. Organised groups spontaneously emerged – such as the ‘*Farmy-Army*’ (comprised of farmers providing machinery and labour for the clean-up) and the ‘*Student Volunteer Army*’ (who self-organised and contributed to the clean-up). A strong community spirit was evident. It is not always the case that virtuous norms spontaneously emerge; with the chaos and breakdown of normal law and order in the aftermath of a natural disaster, selfish and opportunistic behaviour has been observed – in the form of looting and general civil disobedience. On the whole there are more examples of altruism and community solidarity in the aftermath of disasters than anti-social behaviour, but either can spontaneously occur.

Maori are the indigenous people of New Zealand, *Tangata whenua* or people of the land. Iwi have an important role to play in the governance of Auckland volcanoes, with the transfer of 14 *maunga*/volcanic cones to them in 2011. The Maori concept of *Kaitiakitanga* meaning, in part, guardian or land custodians for future generations along with *Tuku* meaning gift, giving, lease or release combine to form what can be understood as Maori property laws that were not automatic, but negotiated between different iwi and hapu (Kawharu 2000). As such, Maori property laws can be included within Williamson’s framework, and are encapsulated (rather simplistically for the purpose of this paper) in Fig.3 through mentioning of *Treaty of Waitangi* negotiations. The Treaty of Waitangi is the founding legal document of the New Zealand nation, signed by various Maori chiefs and representatives of the British Crown in 1840, in which many of these laws between hapu and iwi, and also between iwi and the Crown have been clarified. Iwi play an important role in ensuring continuity between the past, present and future. Iwi knowledge of the local environment provides a rich source of information on past events, not least through the oral history, descriptive place names and mythological stories that were created, with volcanoes (*maunga*) as a central theme and part of *whakapapa* (genealogy) (Marsden 1992). Kawharu (2000) explains that *Kaitiakitanga* assumes that there is an order and a logical consistency where things have their place, in the future, as well as in the past. The world view of Maori, prior to European arrival to New Zealand, (although not unified across all Maori) is holistic and there is integration across space (*Atea*) and time (*Wa*) (Marsden 1992). From this perspective, extended timeframes are not constraints as there is continuity (*Tua-Atea*) beyond any space-time framework. Time is seen as a spiral from a Maori perspective, and historical change has been described as a ‘spinning spiral, where the past never ends’ the different levels of time spiral in and out of each other (Ihimaera 2005). In terms of governance this continuity between past, present and future means decisions are taken with an understanding that “the individual is shaped by the ancestors; each man or woman in turn, is responsible for the shaping of the people to come” (Panny 1998:43). Therefore Maori are unique in governing at level 1 of the above framework, as evident in the Maori Plan for Tamaki Makaurau (Independent Maori Statutory Board 2012) where consideration is given for future generations.

4.1.3 Private Market/Agents

The private market and small businesses are significant stakeholders in managing a volcanic event at several levels. All businesses operate at Level 4 in normal times, but the necessity of businesses providing vital services such as food, water and electricity becomes apparent in the immediate post event phase. Coordination of such business activities is critical to avoid loss of life and to maintain equanimity. Business disruption can significantly impact the entire city/region with flow on effects on the economy and labour market in the aftermath of the event (Kachali et al. 2012). Most businesses in New Zealand are small to medium sized enterprises. There are business continuity issues that have been recognised and are being addressed through the ‘Get Ready Get Thru’ campaign (Department Internal Affairs 2006), although consideration of business continuity can be onerous for small to medium sized enterprises. Under the Health and Safety in Employment Act, businesses have an obligation to their employees to be prepared for an emergency. Organisational resilience is a focus for pre-event planning (Britt et al. 2012; Myburgh et al. 2012), to ensure the minimal amount of disruption after the event, and to ensure that critical services are not affected (AELG 2012).

The insurance industry is one particular business sector that has significant control over the recovery process. It largely determines whether reconstruction will occur and at what pace (Miles 2012). In New Zealand, the insurance industry is a hybrid form – part governed by the private market, with reinsurance companies based off-shore and part governed by the New Zealand government through the Earthquake Commission. The Earthquake Commission in effect acts as insurer of last resort for natural hazards up to a certain monetary limit for land damage. At the time when it was set up, it reduced the risk that re-investors would not cover the risk in New Zealand. The insurance industry argue that greater use of risk based premiums, in tandem with a requirement for preventative measures (where possible) as a pre-condition for insurance cover can act as a good incentive for raising awareness, adapting to and preparing for the risk faced. As such, private insurance is argued to be a key driver in ultimately reducing the potential human and financial costs of natural catastrophes. The issue of transaction costs of the insurance industry in the face of a natural disaster warrants further exploration, beyond the scope of this paper, but needless to say plays a pivotal role in governance of risk and the recovery after an event (Miles 2012). The insurance industry operates predominantly at Level 2 of the framework, but may also extend into Level 3, depending on the duration of the volcanic event and decisions taken after the event about damage to the land and ability to relocate in specific areas.

4.1.4 Hybrid Organisations

Universities, Crown Research Institutes (such as GNS and NIWA) and not for profit organisations (such as the Centre for Advanced Engineering) are instrumental in governance through the provision of information (CAENZ 2009). Increasing information and social learning addresses the ‘bounded-rationality’ problem (Simon 1976), through increasing the capacity to receive, store, process and act on information, improving governance processes. Increasing scientific knowledge can help create an understanding of what would likely happen with a volcanic event. It is however acknowledged that better information does not automatically lead to better governance or management. Research projects, such as DEVORA (Determining Volcanic Risk in Auckland) and IIOF (Facing the Challenge of Auckland’s Volcanism) link scientific research to policy makers to communities, enabling informed policy making. In the context of a volcanic eruption, there can be uncertainty about the impacts and hence uncertainty about the optimal response to a volcanic event. Constant monitoring of a volcano, coupled with the communication of this geological knowledge, is instrumental in the build-up (if any) to an event (Doyle et al. 2011) to avoid panic and unnecessary exodus. Increased scientific knowledge augments the preparation for the volcanic event. Many research projects extend between 3 to 5 years, operating at Level 3 of the governance framework, but often produce outputs which relate to all Levels. Integrating scientific knowledge, along with other knowledge sets held by institutions, iwi and individuals is an important function of these hybrid organisations, where a process of social learning takes place in the exchange of information.

The Auckland Engineering Lifelines Group (AELG) is a voluntary partnership between utility companies, local government, research agencies and other interest groups. Its role is primarily on risk reduction and readiness with regard to infrastructure resilience, providing a synthesis of how utilities are currently provided, while identifying any bottlenecks or likely problems to lifeline services that would arise in the face of a hazard. The AELG recognise the systemic nature of certain infrastructure, including critical transport networks (e.g. the Harbour Bridge, Auckland International Airport, the Ports of Auckland), telecommunication focal points which are critical for a range of services such as finance and banking, energy infrastructure (e.g. electricity generation and distribution lines and pipelines for oil and gas), health and emergency services (e.g. hospitals, police and fire stations) and civic infrastructure (e.g. roads, water and wastewater systems). The AELG operates at Levels 3 predominantly but also Level 2, as the information is useful in the mid-to-long term.

4.2 Phases of Governing Volcanic Risk

The governance of Auckland’s volcanic risk has distinct phases. In this section the perspective from the governance level rather than the perspective of the actors is presented. This provides a linkage between Fig. 2 and Fig. 3. The linkage is based on connecting Williamson’s levels of governance (Fig. 2) with the actors involved in managing

volcanic risk in the Auckland region (Fig. 3). It highlights some of the generic issues of governance in each timeframe and makes a clear distinction between the immediacy of the present and governance over future distant events.

4.2.1 Governance at Level 1

The formal institutions of the state and business/market agents do not govern directly at Level 1. Indirectly, the actions of current governments will influence the emergent social norms in the future, but there is little evidence of explicit long term planning in the current formal institutional framework. As stated above, Level 1 is taken as exogenous by most economists; part of the business culture in a society at any particular point in time. Institutions at this level change very slowly. Informal constraints brought about by a set of moral, ethical and behavioural norms of that society guide the way that society operates. Norms are shaped by cultural precedence, communication within society and mechanisms of sharing knowledge. The rate of social learning and the communication of ideas, history and research, all determine the moulding of these social norms. Interestingly iwi were identified as the only actors who govern at Level 1 in the case study. Cashman and Cronin (2008) comment that repeated volcanism over many generations produces rich webs of cosmology and history surrounding volcanoes. Maori have incorporated volcanoes into the lineage of tribes and individuals, thus good and bad outcomes from volcanism are part of long-term cycles of reciprocity and equilibrium that link modern Maori to their ancestors. Cosmologies and mythologies not only document the attempts of past cultures to recover from the impacts of volcanic disasters, but also provide a means by which following generations can understand, contextualise, and therefore recover from, future volcanic catastrophes. As such, indigenous knowledge shows an ability to integrate extended timeframes into socio-economic planning. It emphasises a role for myth and cultural stories within economic paradigms as they are important nested governance structures. This level allows for the incorporation of infinite game strategies (Carse 1987) into the economic framework, which traditionally sat outside the market economic paradigm, with short-term market goals (e.g. profit maximisation, business continuity).

4.2.2 Governance at Level 2

Governance in the period extending from 10 to 100 years results from established legal processes. Level 2 determines the policy making process, judiciary and bureaucracy of government – and from an institutional economics perspective, property rights feature dominantly (although not exclusively) at this level. Central government agencies are important for governance at this level. Property rights establish a bundle of entitlements and obligations associated with ownership and use of land, resources, and buildings. Rules are established by the political process, and upheld by the state institutions (e.g. dispute resolution process through the judiciary, upholding rights over private property and life).

Historical decisions influence current governance. The establishment of the Natural Disaster Fund by the Earthquake Commission in 1993 is an example. This Fund had its origins in the Earthquake and War Damage Fund, which was set up fifty years prior. This is an example of a decision/rule that was taken seventy years ago, coming into effect in the present day, through a savings fund. At the time when set up, it reduced the risk that reinsurers would not insure property in New Zealand. Rules or laws are constantly amended and updated, although judicial interpretation may take time within a democracy, and is dependent on what is acceptable (social norms) at that time. The New Zealand planning framework faces the challenge of establishing rights and obligations for settlements and urban areas on land that is subject to geological forces. Glavovic et al. (2010) are critical of the current system, as it is more likely to facilitate rather than restrict property development, even in high risk locations.

Land and business developers operate at Level 2, given that housing stock has an average age of approximately 40 years in New Zealand and investment decisions on infrastructure are typically expected to have a 30 year period. Small-and-medium sized businesses operate at Level 2, as they influence employment and decisions to locate in a specific area. The rebuild in Christchurch after the Canterbury earthquake series has shown that the insurance industry can also determine the spatial form of a city after a natural hazard. Notably, civil society is not seen as a significant player in Level 2, although the citizens of the day will be heavily involved in their affairs at that point in

the future. The hybrid organisations that provide information and technical advice influence the governing structures in Level 2. This is a facet of the innovation process as information percolates and is used in future times in a process of social learning (Schumpeter 1934).

4.2.3 Governance at Level 3

In Level 3, governance is characterised by the fixed term contracts established between the actors. Level 3 is the focus for central and local government agencies. If contracts are fixed, and an event occurs that disrupts the normal execution of a contract (e.g. business relocation), frictional problems may arise including legal clarification of the situation, while there may be new trajectories open (e.g. new business opportunities). In terms of the social contract between government and citizens, this is the Level in which ratepayers and citizens can influence the course of action. Participation and input into the political processes is a means of influencing outcomes. This is a period of short term local government planning processes, although they do not necessarily dominate the governance during this time. Universities and information providers operate at this level also – as research findings are communicated and disseminated. The insurance industry plays a critical role in this period with regard to spatial economics after a hazard event, particularly over the decision to rebuild in the same location.

4.2.4 Governance at Level 4

The timeframe during an event and in the immediate aftermath is often a key focus in governance. Despite planning for hazard events, there is not absolute control over the resultant decisions as many individuals spontaneously act under duress leading to new patterns of behaviour. This highlights the inability to centrally control a system. Normal or expected rules of engagement between people can break down, while individuals coalesce to form new governance structures. This is evident in community governance, when neighbours, community groups and organisations, help each other out, but also can manifest in socially unacceptable behaviour. In New Zealand, much responsibility is largely devolved to the local level, with coordination provided by local government. Central government does play a role at this level, as it can declare a state of emergency and establish rules under urgency, bypassing normal legislative process so that recovery work is undertaken swiftly. Emergency legislation would be established in Level 4, but its actions extend into Level 3.

The more diffuse and polycentric governance of Level 4, results in a hive of socio-economic activity. Individuals, communities, iwi, and social groups dominate the activities at this level. This is partly by design – as the ‘Get Ready Get Thru’ campaign encourages New Zealand households to devise a plan to look after themselves for at least three days, deploying survival responsibility clearly onto the individual or household. It is also partly a natural response to a shock or disruption brought about by a hazardous event. Some individuals rely on themselves, while others use their networks of friends and family in such times. Rather than depending on external aid or help from outside agencies in time of a major crisis, disaster mitigation and recovery from an unexpected natural disaster can be dependent on the resources available to the individual and their friends/community. This is a type of ‘informal insurance’, and affected organised communities may be better placed to mobilise political resources in the face of an emergency (Aldrich 2011). Responses from different sectors of the community were explored after the Canterbury earthquakes, and in particular evidence of Maori resilience was studied by Lambert et al. 2012, given that Maori have drawn on traditional institutions such as whanau (family), marae (meeting house), hapu (clan or Maori political unit) and iwi (largest Maori social unit). The extent of concerted community activity may also knit the community together and prevent ‘exit’ from the community in subsequent years (Level 3). This is an example of institutional lock in at this level.

Spontaneous behaviour is difficult to plan for, but should be recognised as a characteristic of the system at Level 4. Increasingly the use of technology (mobile phones and social media) enables effective communication and information sharing for individuals and their connectors, outside the central plans of Civil Defence and Emergency Planning groups. Spontaneous action occurs in non-emergency times also. Hayek (1944 and 1964) is credited within the literature for his focus on the spontaneous emergence of social phenomena. The unintended consequences of individuals’ actions generate a social order. From this perspective, order arises from human action, not human

design – which manifests in language, cultural norms, money, markets and laws (Boettke and Coyne 2005). What happens at Level 4 influences the governance at the other levels. This reinforces the Williamson (1998) framework. In fact there are influences between all Levels. Historical decisions impact on present day outcomes, while current behaviour influences the emergent cultural norms in the future. Each level generates a set of rules, institutions, legislation or social norms that guides human behaviour and how society governs. Evolutionary economists term this construct that connects past and future in an abstract way as ‘path dependence’ (Nelson and Winter, 1982; Vergne and Durand, 2010). Society’s ability or inability to conceive the needs of future generations in distant time frames will affect actions in the present, or what happens within the planning process, and the duration of timeframes that are considered. Some influences may be intended and planned, while there should be awareness that unintended circumstances may emerge.

5. Discussion

5.1 Governance and Change

Consideration of Williamson’s (1998) framework is not only useful for articulating the roles of actors at each level, but also for highlighting the importance of time in governance. The case study of governance of the risk in the AVF confirms a polycentric system of governance. What becomes problematic for governing Auckland’s volcanic risk is the extended geological timeframe, which is traditionally outside of consideration of economic governance. Such institutions are slow to change, yet they can change. A volcanic event can trigger changes to behaviour, and anecdotal stories, legends and cultural norms can emerge to transfer information about a volcanic event to future generations. In the period up to 100 years, laws and regulations can change, which in effect reallocates rights and responsibilities. In the period up to ten years (Level 3), change is easier to effect, as change is constrained only by contractual obligations. Such obligations have a finite term, and can be modified after that time. The behaviour of individual agents, acting independently and spontaneously, however involves a process of continual change. In the context of volcanic risk, this period when individual spontaneous behaviour is a dominant mode of governance is important. It happens markedly during the volcanic event (Level 4), when there is disruption to the ‘normally’ functioning governance structures. It is assumed that behaviour is constrained by the rules existing at levels above. Hence there is room for doing things differently, and for new societal patterns of behaviour to emerge. Governance is not static, but changes through time.

5.2 Time in metaphysics

Time is related to a change through the observation of differentiation of institutions or rules. At a metaphysical level, change is apparent to humans through the presence of motion. The past and future are durations that can be measured, although they cannot be accessed. A further integration with the metaphysical conceptualisation of time may be required, making economic governance frameworks more robust and addressing the nascent effects that differing interpretations of time can have on economic governance. Integration of geological models and socio-economic frameworks have highlighted that the frameworks are not calibrated.

Two different concepts of time are used in metaphysics (Power 2012), both of which have significant implications for economic theory. *Eternalism*, takes the view that all points in time are equally real. This is compatible with the common-sense differentiation between the past, present and future. Eternalism requires an integration with cognitive processes as it requires conscious observation and memorisation of events (Power 2013). The use of time series data in economic theory is an example of the use of the eternalist approach, wherein a sequence of observations is ordered along a timescale. Bebbington and Cronin’s (2011) modelling of events on the AVF is an example of the use of this approach in the context of this case study. They modelled a system according to observed historical trends, systematically ordering the past volcanic events on a timescale. This is a means of ordering, sequencing or ‘making sense’ of observed phenomena. The alternative view of time is *presentism*, where only the present is considered real. The future and past do not exist, and from this perspective, a passage of time is an illusion (McTaggart 1908). It is conceivable that a person experiencing a traumatic shock such as a volcanic event, where

personal survival is imminent, may view time only in the present. Self-preservation may lead to opportunistic behaviour, which may not be exercised in normal times. Discounting the risk of getting caught for socially unacceptable behaviour in the wake of a natural disaster can result in impulsive decision making. Such presentism shows an inability to rationalise future consequences of behaviour. As geological time extends across generations of humans, presentism would also disregard the risks and probabilities of a volcanic event occurring. Taken to the extreme, presentism would imply that future decision taking is inconsequential, and decisions should be taken in response to stimuli, purely in the here and now.

Intuitively, the eternalist approach is more akin with governance models, as we do think strategically about the future, make inter-temporal trade-offs, create plans beyond the immediate here and now. There are instances when impulsive decision making prevails. There seems, however, to be a limit to the length of time that we have consideration of future time (intergenerational equity). Williamson's framework has shown that in the context of the AVF, the planning timeframe is relatively short – planning is undertaken mainly in Level 3 and 4, with little to no planning extending into Level 1 and 2.

5.3 Cultural views of time

There are distinct cultural views of time and connections between them. Maori conceive integration across space (*Atea*) and time (*Wa*), an integration that was similarly reached by Einstein's theory of special relativity in quantum theory in the twentieth century. Other cultures and people regarded space and time as a single concept – the Incas referred to it as *pacha*, and the people of the Andes kept this understanding, which has been translated as 'circumstances', 'conditions', 'world', 'earth' and secondly as 'time', 'era' (Skar 1981). How a society conceptualises time can have profound impacts on the resulting institutions and governance structures, especially if time is considered finite rather than infinite (Carse 1987). If decisions are taken across time, consideration for the best outcomes in future time periods will be made, rather than optimising outcomes in the immediate time period. This has been studied within economics, for example in the life cycle income hypothesis, which suggests that consumption patterns are spread over the long-term, through savings (Modigliani and Ando 1957). There is a need to avoid temporal short-sightedness in economic behaviour, particularly with regard to resource planning (Hardisty et al. 2012) in order to have consistent outcomes in the future. Henrich et al. (2010a, 2010b) go further and stress the considerable variation among human populations not just in terms of language about time, but in diverse domains, such as visual perception, analytic reasoning, fairness, cooperation and memory which increase complexity in the formulation of economic behavioural models. Their work is seminal in showing that it is not unusual to have alternative views of concepts such as time, however current paradigms tend to overlook the diversity. This leads to imperfect models and assumptions in economics.

It is clear that just as there is diversity in institutions, there are also different ways of conceptualising time across individuals and cultures. There are unique cultural modes of making inter temporal trade-offs in a particular time, place and social group. As evidenced from analysing the governance of the AVF according to different levels, the planning horizons extend to between 30 to 50 years, and then only poorly, with more certainty of formal rules in the period up to 10 years. Governance beyond this time period is not catered for in the formal planning processes. Governance in the immediate timeframe after a volcanic event is reliant, although not exclusively, on the coordinated spontaneous behaviour of individuals and communities. The challenge for policy is to create structures that can span all the governance levels from the outset, by explicitly clarifying the trade-offs associated with time.

5.4 Polycentric governance through time

Polycentric governance structures are the norm in most situations. There is not just one single authority or one set of rules which explain how a situation emerges or unfolds. A polycentric system is characterised by many centres of decision making that are formally independent of each other. There are 'nested jurisdictions' of actors and competencies with differing functions. These decisions are not chaotic or competing, but polycentrism is a feature of complex decision making processes, a system of ordered relationships that underlies the fragmentation of authority and overlapping jurisdictions (Ostrom 2005). Polycentric systems are more likely to be flexible and adaptive –

having the incentives that lead to self-organised, self-corrective institutional change. However, there is little evidence to indicate that such a flexible approach will enable effective governance in the long term, and indeed the need for analytical tools to study institutional change has been identified (Ostrom and Basurto 2011). That is not to say that a polycentric approach cannot provide effective long term governance, as it initiates an emergent governance trajectory and pathway, but is nevertheless can be constrained by a myopic human time scale.

With a volcanic event in Auckland, the question arises as to the role and response of the state and its agencies along with the role and response of residents and communities. Certain rules and courses of actions may be required, for example in the days and hours leading up to a volcanic event, which are not required in ordinary time. For example the evacuation of people from a threatened area, provision of shelter, coordinating transport and supplying basic food and water necessitate certain action in the days immediately following a natural disaster. In terms of rebuilding parts of the city affected by a natural hazard, a different set of rules and *modus operandi* will be required – related to spatial planning and construction. The viability of resilience in the longer term may require functioning insurance markets to ensure that risks can be spread and that there is an ability to fund future natural disasters. Arguably there is not one optimal governance structure to be pursued, but numerous appropriate governance levels, according to the different requirements that emerge in a post-volcanic period. The challenge is to build on and utilise emergent governance structures, while calibrating the different levels (polycentric governance) to ensure continuous flow between levels (across extended timeframes). This can be seen as a tension between emergence and control. As such, it manifests as a problem of leadership in the context of governing for hazards.

5.5 Leadership

In terms of planning for long term outcomes, the issue of leadership needs to be addressed. Governing a volcanic risk on an urban area such as Auckland requires longer term thinking, including analysing the vulnerabilities and alternative options for the plan of the urban form. Sometimes referred to as strategic or spatial planning, this process requires a synthesis of all available information, with decisions taken to mitigate risk and minimise damage in the face of a volcanic event. Polycentric governance does not preclude strong leadership, but spontaneous processes do not guarantee its emergence. Leadership is not commensurate with a centralising authority, but in the context of governing a volcanic risk in the long term, it requires taking strategic decisions by a mediating agency, which may be for example result from a particular individual or community group. Much of the literature on leadership concentrates on leadership styles on performance, such as participative, supportive or directive leadership (Rotemberg and Saloner 1993), rather than leadership for particular outcomes – which is of direct relevance for governance of volcanic risk, when the timeframes extend beyond political cycles and potentially across generations. The importance of leadership should be included in governance structures and frameworks, as it can be the touchstone for overcoming long term planning problems. The logical place for such leadership to be transpire would be in the planning process, where the timeframes could be extended, while also establishing a pathway to govern these longer term outcomes.

5.6 Governance through statute

The incorporation of longer term plans into the legislative framework is a means of bridging long term goals and increasing resiliency across generations. Use of spatial planning for volcanic risk connects Levels 2 and 3 to Level 4. Interestingly, laws are not immutable and can be amended or changed. To ensure that laws continue into the future, they need to be universally accepted and turned to custom. This is not a process that can be imposed, but emerges through action and behaviour. Spatial plans are static documents, which get updated through time. While spatial plans exist for Auckland (but not elsewhere in New Zealand), there is a lack of explicit temporal planning, which pays attention to the sequencing and effecting of change. Integrating processes with long timeframes, such as geological models into governance processes, highlight the need to be more specific about timeframes within policy formulation and analysis. This paper identified that economic governance requires a closer look at what central assumptions are made about time and change, and how these are implicitly adopted in our management and planning processes.

6. Conclusion

The occurrence of another volcanic event seems certain from the AVF. The timing of that next event remains enigmatic. New Zealand legislation mandates the preparation and planning for natural hazards. Lessons from responses to natural hazards are continuously integrated into planning cycles and best practice management in New Zealand; most recently after the series of earthquakes beginning in 2010 in the Canterbury region of New Zealand's South Island. A natural hazard is by definition unpredictable. How the hazard is governed may enable a reduction in the damage and impact of the hazard. The challenge for governing those hazards is how to incorporate timescales that are vastly different into planning processes. Geological scales range from the thousands to millions of years, whereas economic theory of the market focuses on outcomes in the present or near future brought about by the decisions of people. How society conceptualises time and what emphasis is placed on past and future times influences the governance structure and the ensuing institutions of that society.

This paper contributes a framework that integrates earth sciences, volcanology and geology into social and economic governance. The paper highlighted the importance of timescales, timing and sequencing of events. These can oftentimes be overlooked within economic frameworks, and in general, time is not adequately treated in economics. A framework from New Institutional Economics was chosen to structure the formal and informal institutions or rules that govern Auckland's volcanic risk. The paper extends the analytical use of economic governance options under radical uncertainty – in this case through stressing the importance of the 'long-run' or timescales more aligned with event timescales. Little formal planning was identified as having been undertaken within Auckland for the medium-to-long term. This is not a criticism of the planning system which is complex, but more of a cognitive limitation in our current planning paradigm. In the long run, there are many different forces, affecting our complex world, to consider. This makes the formation of mental models of the long run situation difficult. The difficulty may arise from a narrow view of time, which shapes the ensuing governance structures. Alternative constructs of time exist in different cultures within New Zealand (e.g. the integration of space-time into one concept), and inclusion of such concepts into economic models would change how we govern. Maori, who have this concept of space time, were the only group of people identified in the context of understanding the AVF who govern at this long-run level. The political institutions, local and central government, predominantly govern in the period up to 10 years, with certain institutions extending up to fifty years. Relationships between actors at different levels provide valuable insight into how we might structure future risk mitigation within the AVF.

The governance structures put in place to deal with hazards are well planned on the AVF, and operate particularly prior to an event. A system of polycentric governance was identified, and much of the responsibility for governance during a natural hazard event is transferred onto individuals and communities. This is a rational approach to prepare individuals and create resilient communities that can be independent in the face of adversity, who can survive in case of disruption to normal utilities and services. The governance structures in place in New Zealand are path dependent – they have primarily evolved out of learning from the management of previous natural hazards. However, because natural disasters (as opposed to repeated natural hazards) are so infrequent, there is limited past experience of widespread disruption.

In the short term immediately following a volcanic event, it is reasonably easy to conceptualise what might happen, and establish institutions of how to deal with the disaster. The Canterbury series of earthquakes makes it clear that preparation is needed at a household/community level, thereby strengthening the governance structures of civil society. The response from communities in Canterbury showed that polycentric governance was effective. Leadership can emerge from within communities, enabling coordination in the immediate post event period. It is difficult to plan for all contingencies in the complex post-event climate, and particularly to plan for strong leadership. The framework presented in this paper shows a continuity and integration across all governance levels. These institutional structures need to be integrated and continue through time, and as such leadership or guidance should come from within the existing institutional structures. They should not be imposed, as the connectivity will

be lost. The longer term responses are more difficult to govern, such as formally establishing contracts, organising and managing reconstruction and rebuild. The post-event climate is characterised by uncertainty and complexity, creating problems for governance. Leadership or coordination is critical in the post event period, as investment decisions are taken on behalf of future generations also.

The governance of volcanic risk in Auckland is a polycentric system. There is not a hierarchical concentration of management, but responsibility for outcomes resides with numerous groups of people and organisations that become operational or govern in distinct phases. This paper has recognised that governance in the long term requires strengthening. To do this, economic frameworks need to look beyond the traditional formulation of time, and change some of the assumptions relating to inter-temporal trade-offs and discounting future events. Alternative paradigms of time exist and there is a need to incorporate these into economic frameworks, to mitigate the negatives associated with natural hazards. In doing so, volcanic hazard governance will be strengthened, and the connectivity of actors will be maintained through time. Such an approach has relevance for framing the practical management of low-probability but potentially high impact natural hazards. It is also of relevance for high-probability and high impact events such as climate change, where the changes take effect over generations rather than for the current generation. Although it is not possible to determine the value sets of future generations, it is possible to envisage the changes they are likely to face, and make decisions now that are informed by an economic framework with a range of timescales. Such an approach is critical to finding solutions to the global problems that humanity faces, and challenges the myopia that pervades neoclassical economic analysis.

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