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Applying Complexity Theory to New Zealand Public Policy

Principles for Practice

Introduction

Interest in the development of complexity theory and its application to policy and social sciences has been accelerating over the last decade.

Growing out of developments within natural sciences since the 1960s, including chaos theory, complexity theory is increasingly being applied in organisational studies (Caldwell, 2006; Richardson, 2005; Stacey, 2003); public health (Durie and Wyatt, 2007); education studies (Zellermayer and Margolin, 2005); and policy studies (Bankes, 2002; Callaghan, 2008; Dennard, Richardson and Morçöl, 2008; Klijn, 2008; Morçöl, 2002, 2010; Sanderson, 2006, 2009).

Drawing on three pieces of recent New Zealand research, this article aims to provide an introduction to complexity theory for policy practitioners and researchers, highlighting principles of complexity theory relevant to improving policy practice and the positive impact of interventions. The studies have used complexity theory to understand and explain policy processes and the factors within those processes which shape the design, implementation and outcome of policy interventions. Eppel (2010) examined the contribution of complexity theory to understanding and explaining policy processes, using tertiary education policy processes 2000–2008 as the empirical case. Walton (2010) sought to identify policy options to support the promotion of healthy nutrition within primary school settings. Matheson (2008) investigated the implementation of two community-based health interventions carried out in different New Zealand communities. The findings of these three projects are described in turn. The paper concludes by identifying some of the implications of these research findings for practice. We also highlight areas of policy practice where continued development of both theory and methods is required.

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Key concepts in complexity theory

Complex(ity) has become a much-used word in contemporary public policy discussion but the meaning and implications of complexity have been less commonly elucidated, and rarely tested through empirical study. Reference to complexity has become synonymous with intractable policy problems and little progress in achieving outcomes. However, complexity means much more than something that is complicated because it has lots of components. Yes, a complex system does have many parts, but these parts are not independent. In social systems which public policy seeks to influence, the parts of a system might be individual people, or they could be formal aggregates of people (such as organisations) or less formal groupings (such as lobby groups, user groups, ethnic groups) (Byrne, 1998). Complex systems are self-organising and interdependent – each individual (re)acts to their own interpretation of events as they unfold, and to what they think will happen next, while also adapting to the actions of others around them (Kauffman, 1995; Waldrop, 1992). The capacity of complex systems to self-organise suggests that

action by individuals and organisations are important considerations in analysis 'of policy' and 'for policy' (Hill, 1997). However, the action of individuals will also be influenced by individuals' understandings of context, available resources, system history and interacting systems.

Complex systems can be conceptualised at different levels of aggregation. For example, the economy as a whole can be considered a complex system, but so too could financial markets, groups of firms making up an industry sector and labour markets within the economy. In these examples, the complex systems at a lower level of aggregation than the whole economy should not be thought of as hierarchically subordinate, but rather nested within and interacting as parts of the whole (Byrne, 1998). To understand a complex system, the location of the system of interest in respect to other complex systems is required (Walby, 2007). In the research examples presented below, primary schools, geographic communities and policy communities are all considered complex systems, which interact with other complex systems.

Complex phenomena of interest to policy makers, such as employment trends, chronic disease or educational achievement, can be thought of as emerging from the interactions of parts within a complex system as a whole (Morçöl, 2002). This means that 'of' and 'for' policy methods which focus on parts of the system in isolation are unlikely to be useful for understanding the existence and implications of complexity. In the research examples described below, tertiary education policy processes, interventions aimed at reducing health inequality, and the design of policies to encourage healthy nutrition in children are examples of complex systems which give rise to emergent phenomena.

Thinking about policy, and how it is designed and implemented, requires an understanding of change in complex systems. There are patterns of interdependent influence between the components of a complex system which are called feedback loops. Sometimes a desired change might not occur, because the feedback loops between the action of one component and the reaction of others in response cancel each other out (a negative feedback loop). The resulting overall macro appearance is one of stability. At other times an action by one component can prompt a response which magnifies the effect of the initial action (a positive feedback loop) and a pattern of escalating or growing change is seen.

Positive feedback loops are a necessary part of change, but the problem for policy designers and implementers is that the patterns of influence and interaction between the parts do not follow predictable rules: they are nonlinear. That is, outcomes are not proportional to inputs, nor can they be predicted from the parts of a system or their initial actions. A simple example is that when an individual speaks, the response of listeners cannot be predicted with any certainty, much less the direction a following conversation might take (Watzlawick, 1984).

The boundaries of complex systems are fluid and difficult to define. In human social systems, boundaries are constructed by the human 'components' that make up the system. Therefore, understanding the boundaries requires sense-making (Kurtz and Snowden, 2003; Weick, 1995; Weick and Sutcliffe, 2007) and boundary critique (Midgley, 2000). Another feature of complex systems is that they have a history, and this history continues to influence what happens in the future. Thus, social systems will continue to change, long after a stimulus has ceased, because the stimulus has affected the feedback loops and therefore the trajectory of change in the system.

As the parts of a complex system adapt to each other, self-organise and co-evolve over time, these processes of self-organisation can lead to the emergence of entirely new phenomena – new patterns or new groupings as a result of changes in feedback loops (Kauffman, 1995). Thus change in complex systems is not necessarily related to any external stimulus at all, or to the size of the stimulus for change. So-called unintended consequences are 'normal' in complex systems and should be expected.

Feedback loops can keep a system in a stable pattern, called an attractor. However, it would be wrong to think of a system displaying a stable pattern as in equilibrium (Byrne, 1998). Complex systems actually operate on the edge of chaos – 'far from equilibrium' – and can be easily disturbed to operate around a new attractor when feedback loops are disturbed (Kauffman, 1995). When there are a lot of attractor patterns operating, the system appears more chaotic. Change in complex systems, such as organisations, or public sector domains, including education and health, is brought about by changing the feedback loops and the attractor patterns they make (Caldwell, 2006; Mitleton-Kelly, 2003; Stacey, 2003). Doing this in a manageable way involves monitoring both positive and negative feedback loops and attractor patterns, looking for small indicators of change to the patterns operating and remembering that small changes can have large effects (both desired and undesired). Therefore, achieving desirable change means allowing some small changes to continue to grow because they are taking the system in the desired direction, and undesired change needs to be counteracted or disrupted (Weick and Sutcliffe, 2007).

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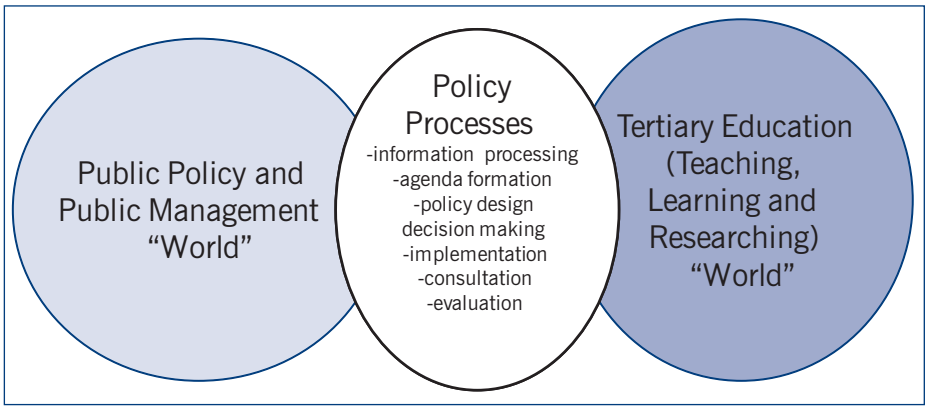
Application of complexity theory

Not all public policy problems or public management sectors are complex; however, failure to allow for complexity when appropriate can have dire effects,

Figure 1: Interacting Systems in Tertiary Education Policy Process



resulting in not only unintended but also unwanted policy outcomes. As a general rule, the more components (people, organisations, groups), and the more diversity between those components (e.g. ethnicities, cultures, locations), the greater the complexity. Complexity theory is best used when the phenomenon or problem being studied is multidimensional and its causes are difficult to identify (Richardson, 2005; Westley, Zimmerman, and Patton, 2006). In current policy literature these types of problems are often referred to as 'wicked problems' (Ritter and Webber, 1973; Scott and Baehler, 2010). The three studies described here provide examples of the notion of complexity and wicked problems in public policy. Space does not allow a detailed description of these three studies. Full references to the sources are provided at the end of this paper.

Study one: Using complexity theory to understand policy processes

The Labour government in 2000 initiated a series of policy changes in tertiary education. Interviews with 65 participants involved in the policy processes were used to build an understanding of how these occurred. Complexity theory provided a holistic lens for understanding and explaining these policy processes and how they continued to be influenced by policy changes that preceded the change of government.

Firstly, there is more than one complex system at work in policy processes. Tertiary education, consisting of many individuals (e.g. students, teachers, researchers, governors) able to make decisions, and many organisations (e.g. polytechnics, universities, wānanga, private providers and industry training organisations) is a complex system because all these parts interact with each other in nonlinear ways that keep changing over time. Furthermore, these systems are undergoing continuing changes in response to extant policies and in anticipation of future policy change.

Government and its public management organisations are also a complex system, in which ministers, members of Parliament, public sector agencies such as the Ministry of Education and the Tertiary Education Commission, agencies involved in other policy domains, and political and parliamentary processes interact. Policy processes bring these two sets of complex systems together into a third complex system, as issues are identified, agendas set, solutions decided, and policies implemented and evaluated (see Figure 1). The language and concepts drawn from complexity theory help to create a holistic picture of the dynamics which exist within these systems and the interactions between them in policy processes which is helpful to our understanding of these.

The nonlinear dynamics of tertiary education policy processes are understood through the concepts of feedback loops, attractors, co-evolution self-organisation, emergence and the history of system changes. Examples of these include:

- non-linear effects of changes in funding policies
- co-evolution between different parts of tertiary education, such as industry training organsations and polytechnics
- self-organisation and emergence of new courses, new patterns of student recruitments and enrolments
- the continuing influence of policy decisions made by previous governments, even when a new government has instituted its own policy changes.

Study two: Promoting healthy nutrition through primary schools: a complex analysis

This study identified a 'portfolio' of interventions across school, home and community settings which, taken together, might support primary schools to effectively promote healthy nutrition. The primary schools themselves were considered complex systems, nested within and partly defined by other complex settings – households and communities, and also the national policy context.

The food environments of five case-study primary schools within the Wellington region were mapped using interview, documentary and observational data. Each school food environment was considered a complex system made up of local- and national-level elements. Intervention options to improve the school food environment were identified across case studies, with support for interventions gathered from school principals as local-level decision makers. Interviews with 16 policy makers considered the national-level context of the interventions.

Eleven interventions were identified for inclusion in the portfolio. Figure 2 shows this portfolio mapped on a generic primary school system. Each of the five primary school systems varied in their composition and local context, meaning that interventions are unlikely to have an equal impact across schools, supporting a diversified portfolio approach. The number of system elements potentially affected by at least one of the portfolio interventions is seen to increase the likelihood that the school systems will change in the desired direction and positively influence children's diet (the emergent outcome).

To inform implementation, identified interventions were prioritised based on (1) the level of support from case-study school principals and policy makers, (2) evidence of effectiveness from international literature, and (3) theoretical likelihood of them having

an impact on the complex system of childhood nutrition. These criteria acknowledge that agency of actors within the system is important for implementing policies and system change. Also, while the impacts of interventions in nonlinear systems are somewhat unpredictable, research evidence can still be used to guide action.

The influences on children's diets are viewed as multiple and diverse across the nested systems, with dietary practices viewed as emergent. Therefore, policy options to support the role of primary schools in promoting healthy nutrition need to consider the interaction between the nested systems involved.

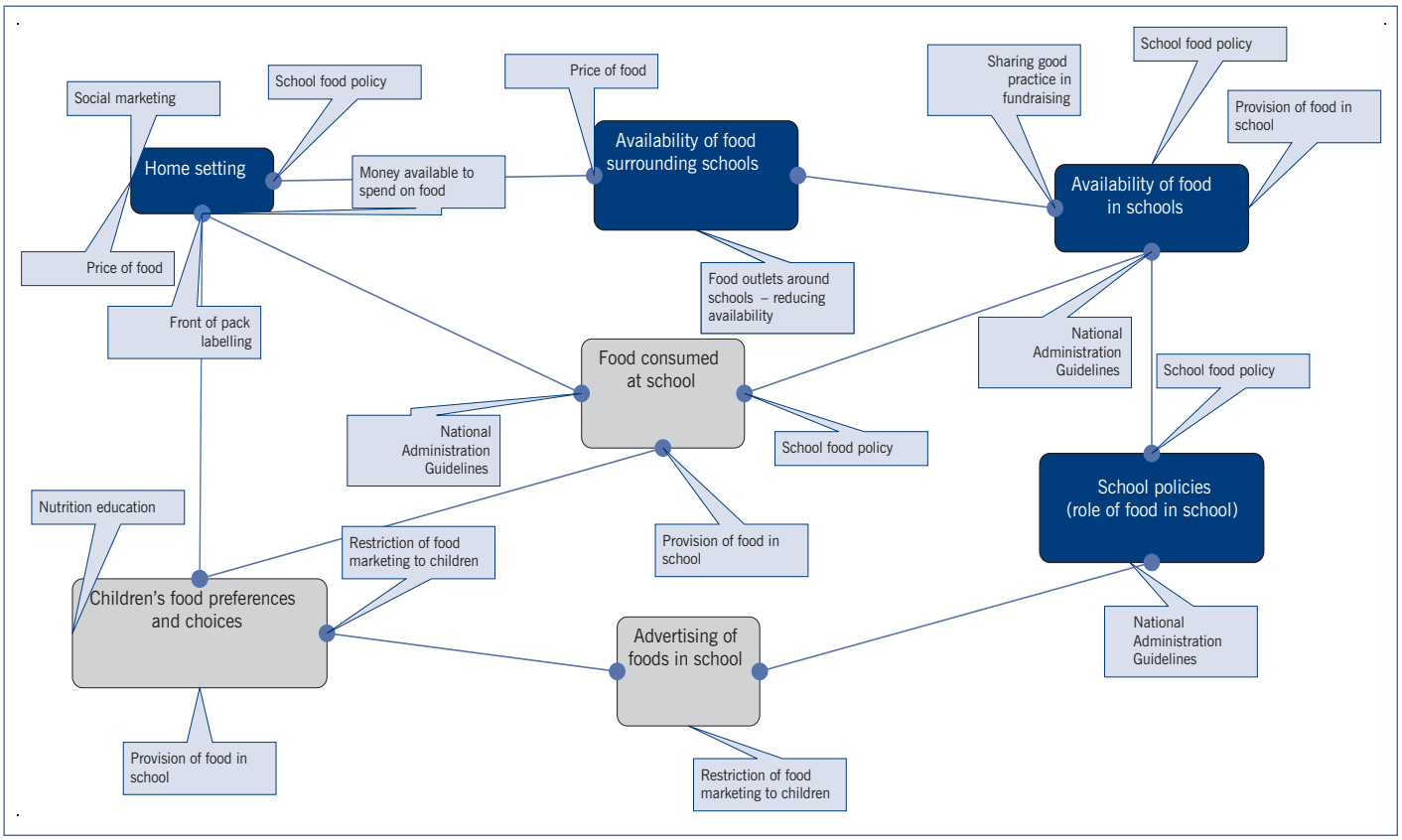
Study three: Treating communities for health inequalities: complexity matters

This study examined two cases of interventions aimed at reducing inequalities using the concepts of complexity theory as an analytical lens. The framing of the context for this study included the measurable evidence of health and social inequalities, in particular the associations shown between socio-economic status (SES), ethnicity and geographic area. The current evidence, however, is not overwhelming on how to effectively intervene to reduce these observed differences in outcomes between social groups (Oglivie et al., 2005; Petticrew et al., 2009). The transfer of knowledge – from understanding more about population-level social patterns to informing intervention approaches – has been slow.

This study involved a comparative case study of two community-based interventions and their implementation. The first, implemented in 2000, was the Housing, Insulation and Health Study (HIHS) carried out by a university-based research team. The HIHS was a community-based randomised controlled trial of the health effects of insulating houses. The second case, implemented in 2005, was the Intersectoral Community Action for Health (ICAH) intervention, funded and monitored by a government agency. The ICAHs were community-based initiatives aimed at the co-ordination and facilitation of community relationships and action around local health issues. The data sources for the study were primarily documentation relating to the interventions and in-depth interviews with key informants from varied organisations. The participant organisations included government agencies and local organisations within six New Zealand geographic and socio-economic communities: Otara, Nuhaka, Mahia, Kapiti, Porirua and Christchurch. Information on the health status of each of the areas was also gathered and used in the analytical process.

The study found that complexity theory offered useful concepts for illuminating the influences of these two interventions. These concepts included weak and strong emergence, system trajectories, system bifurcation, feedback, sensitivity to initial conditions, and attractor states. Through these concepts it was shown that the two interventions operated within a context of feedback between elements within the communities involved, and this context may reinforce the circumstances of disadvantaged communities, undermining the intentions of the policy aims. Feedback mechanisms included the relationship between the community's social organisation (particularly its ethnic and social diversity), the activities of

Figure 2: Primary School Setting Map with Identified Interventions



government policy organisations and the geographic structuring of opportunities for social action (for example, the workings of local government and the existence of advocacy and lobby groups). This has significant implications for the design and practice of interventions to reduce health inequalities, shifting the focus to the way in which interventions themselves may interrelate with the local context.

The study showed that complexity theory provided a systematic way to explore and understand relationships between social levels, suggesting that instances of feedback, between 'communities' and the 'whole system', may in practice be more subtle, relationship-focused and context-specific than traditional thinking allows.

Implications of complexity theory for policy practice

The policy focus differs across the three studies, which include analysis both of and for policy, and across policy design and implementation. Study one investigated the policy process as a whole, while study two focused on the use of complexity theory for policy design, and study three sought to understand implementation and its relationship to policy outcomes. The studies also come from different social policy areas (education and public health) and are not comparable at the level of detail. However, looking across the three studies it is possible to identify some common insights that the complexity lens provides which might be of use for public policy and management practitioners.

We have identified the following implications of complexity theory for policy practice from the three research projects described and the complexity literature more generally. While the implications have been split into ten points, in reality the implications are closely related to one another.

1. Complex systems self-organise: whether you plan for it or not, surprises will happen

Complexity theory views all but the most simple policy problems as emerging from a dynamic interaction between cultural, economic and political systems which make up New Zealand and go beyond New Zealand, such as the current financial crisis and its effects. Emergence has its origin in the capacity of these systems to self-organise and take on systemic properties that cannot be reduced to solely economic, psychological or cultural factors (Morçöl, 2002). Any policy intervention requiring the action of people is likely to be complex in its nature because of the self-organising capacity of individuals, informal (families, whānau, neighbourhoods) and formal groupings of people. This is particularly so for achieving long-term goals, where the numbers of components (people, communities or organisations) and their interactions increase over time. While surprises will happen, complexity theory provides an understanding of how social systems change over time. Such an understanding allows for policy action that over time should move systems in the desired direction of change, although highly prescribed targets are unlikely to be met.

2. Boundaries are open, fluid and socially constructed

To enable policy work and public management to be done, politicians, public managers and policy analysts create boundaries and define limits of social systems. However, if we are not aware of the artificiality of these boundaries then we risk missing factors that could trigger large responses in a particular policy area, due to their exclusion from the policy frame of reference. Boundary critique from multiple perspectives and fluid boundaries can help avoid problems (Midgley, 2000). Boundary critique involves exploration of the boundaries between individuals, groups and organisations from multiple perspectives. Working with and across boundaries requires knowledge of how the boundaries that exist have been created and are maintained by social processes. In practice, collaborative interagency processes may be required to enable the problem and its solutions to be viewed from multiple perspectives and to sense a way forward (Eppel, Gill, Lips and Ryan 2008).

3. What can be known about complex systems is limited

Public managers also need to be aware that when dealing with complex systems there are limits to what can be known and predicted. Systems will go on self-organising, adapting and changing over time, which means that attempts at purely rational approaches to policy design and analysis are problematic (Lindblom, 1979). Sanderson (2006, 2009) calls for an ongoing, reflective and incremental policy process to manage the unpredictability of complex systems. Sense-making techniques are one approach to dealing with the uncertainty of complex systems (Kurtz and Snowden, 2003).

4. Policy processes are continuous and design and implementation go hand in hand

Research cannot prospectively tell us what will work, and for whom, in all contexts (Sanderson, 2006; Byrne, 2005). The conclusions from our three complexity-informed research projects support the idea of policy as an ongoing process with no definitive beginning or end. The policy domain concerned will be influenced by events that happened in the past in ongoing ways that are difficult to detect. For example, the tertiary system continued to be affected by policy changes made during the early 1990s well into the next decade. Therefore, we need to think of policy design and implementation as more continuous and iterative processes that go hand in hand. This does not preclude first-principles re-design of policy to reflect changing societal expectations or values, but the history of previous changes and their ongoing effects need to be considered. In fact, ongoing participatory processes (see point 9) and iterative design-implementation cycles may reduce the need for periodic first-principles reviews, as societal changes are more regularly included in incremental change.

5. Ongoing, reflexive 'real time' evaluation practice is necessary

As mentioned above, complex systems will continue to adapt and there will be co-evolution between the policy and the system involved. Moreover, there will be continuing uncertainty and emergence of new phenomena as a result of complexity. Therefore, complexity requires an understanding of policy processes as ongoing and evaluation needs to be real-time and reflexive to feed into an

ongoing policy process (Matheson, Dew and Cumming, 2009). The role of evaluation should be to support this implementation–learning–development process (Sanderson, 2009). The other nine implications listed here also impact on evaluation practice. For example, how can evaluations meaningfully capture local variation and context while providing information for national-level policy development? Should evaluation be conducted by external researchers, or integrated within policy development/implementation teams? Possible answers to these questions may be gleaned from sympathetic evaluation methodologies, such as developmental evaluation (Patton, 2010) and realistic evaluation (Pawson and Tilley, 1997).

6. Local flexibility in intervention design

Differences in conditions, such as geographical and social context, are likely to have significant and unexpected influences on policy interventions over time. No two communities will be identical and small differences matter. Nationally-directed policy action is likely to have limited ability to respond to local contexts, including subtle differences in the initial conditions and the specific people and organisations involved. For example, Matheson (2008) found that communities experienced differences in access to policy processes, and that different communities are likely to require different policy designs, implementation and expectations of outcome. Locally-directed policy action may be more successful in responding to local contexts, but provides for a national approach to policy and resource allocation.

7. Information in complex systems is highly distributed and fragmented

Information exists in the consciousness of individuals and the collective memories of organisations within policy processes. Interactions between individuals and organisations help to reveal the partial information held by individuals. Interactions between individuals can be turned into participatory processes of constructive sense-making and learning (Kurtz and Snowden, 2003; Weick and Sutcliffe, 2007). In the three research examples discussed we saw the benefits of collaborative approaches to gathering information, such as sense-making and learning as an ingredient of an ongoing sense-make, learn, plan, do, re-evaluate cycle. But, as Matheson (2008) also found, opportunities for feedback that allowed the exchange of information between individuals and organisations were often different for different communities.

8. Complexity implies that there is no one solution to any problem

Complex problems have multiple causes and it is unlikely that there is one best intervention to solve a complex problem (Dennard, Richardson and Morçöl, 2008). It is more likely that there are a range of possible interrelated actions, and the role of the public manager is to facilitate a process that gives rise to a coherent, self-reinforcing web of reactions that move the overall system in the desired direction. For example, Walton (2010) identified a portfolio of interventions to promote healthy childhood nutrition within a primary school setting. A portfolio approach was important for two reasons. First, because the influences on children's diets are varied and wide a range of interventions are also required. Second, because the configuration of influences operating within a school varies between schools, a portfolio increases the likelihood that interventions will have an impact within a wide range of schools. So, while not all interventions will be relevant for all schools, it is likely that across the portfolio interventions will be relevant for a large majority of schools.

9. Participatory policy practices go with complexity

In relation to the way information is gathered and responded to, complexity provides a further argument for participatory policy practices in which different perspectives and kinds of expertise (technical, practice and experience) from across the system are brought together and acted on. No one person or organisation is likely to have sufficient information or resources to understand a complex system. This is a common factor in the findings of all three of the research projects.

10. Simple complex systems can be modelled, but the benefits of modelling are limited

Computer models can aid understanding of the ways in which a complex system might evolve over time, and are one way in which complexity theory can be used predictively. However, such models are limited in the extent to which they can fully replicate the complexity of real-world situations (Byrne, 2005). While agent-based modelling of scenarios may be a useful advance over other types of modelling, it should only be considered as one piece in the sense-making puzzle and perhaps best used to stimulate deliberation (Richardson, 2008).

Taking complexity thinking in policy processes forward

There has been a trend in the policy literature over the last 30 years towards greater recognition of the social processes involved in policy design, implementation and means by which policies achieve outcomes. Others have proposed different approaches to take this dynamism into account: for example, incremental analysis over comprehensive rational analysis of problems (Lindblom, 1979); multiple streams for viewing policy agendas (Kingdon, 1995); deliberative policy analysis (Fischer, 2003; Hajer and Wagenaar, 2003); and the recognition of horizontal networks (Kickert, Klijn and Koppenjan, 1997). To date, others have used concepts from complexity theory selectively, but a complexity-based theory of policy processes has yet to be fully articulated (e.g. Butler and Allen, 2008; Gerrits, 2010; Teisman, 2008). Eppel (2010) has argued that complexity theory can provide a holistic lens for explaining and understanding policy processes, one which complements existing theories that have sought to understand the implications of social complexity and interdependency in policy processes. Walton (2010) and Matheson (2008) demonstrate the usefulness of complexity concepts for policy research, providing a method that works with multiple complex social systems and policy domains to understand and guide policy action.

Much existing thinking about policy processes and methods of policy analysis

does not take sufficient account of dynamism, self-organisation, adaptation and emergence. As we come to understand human society as interacting complex systems, there is a need for rigorous evaluation of the compatibility of existing methods of policy analysis with this view. At the very least the existing methods lack the language and the concepts to explain phenomena that are likely to be encountered in complex systems, and pay too little attention to these aspects. At worst, they ignore the dynamism which gives rise to unexpected changes and leads to unintended and unwanted outcomes. A complexity perspective does not mean that all existing analysis methods need to be abandoned. It does, however, call for careful selection of multiple methods, diverse perspectives and an iterative approach to policy design and implementation. We would recommend that practitioners carefully assess the methods they are using for their sensitivity to ongoing, endogenous changes in systems.

Acknowledgement of uncertainty, ambiguity and paradox in many social policy problems presents challenges in terms of the current structures and processes of government. In particular, while accountability and funding appropriations continue to be largely in organisational silos, the management of uncertainty and emergence of new and unexpected outcomes will remain problems. These issues are not new (State Services Commission, 2002), but complexity theory offers new insights into how we might design and deliver public policies more effectively. Involving the appropriate technical, practice and experiential expertise in policy design and implementation is likely to go beyond the boundaries of any one agency and their accountabilities, and also extend into organisations and individuals outside government. New ways of configuring leadership, performance and financial accountability are needed to match the complexity of the problems being solved and the information and other resources needed for their solution.

If we take complexity into account and policy processes are undertaken in ways that reflect this, then timelines are likely to look different. Initial phases might take much longer; the process might seem back to front in that some 'implementation' activities might precede policy design; more participants in policy processes might extend timelines, but might also promise more deeply entrenched and enduring solutions.

The three research examples presented here illustrate the utility of a complexity approach for understanding policy design. The implications of complexity are far-reaching in challenging policy/implementation/evaluation barriers, promoting participatory policy frameworks and accepting uncertainty from policy action. Our findings on the implications of complexity for policy analysis and public management echo many of the implications arising from network (e.g. Kickert, Klijn and Koppenjan, 1997) and responsive government arguments (e.g. Fischer, 2003). Complexity thinking adds new and useful tools for a more holistic understanding of public management.

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More information on the healthy nutrition through primary schools study can be found at http://www.wnmeds.ac.nz/academic/dph/research/heppru/research/childhood.html. The School of Government thesis and seminar presentations can be found at http://e-government.vuw.ac.nz/events.aspx#Elizabeth and http://researcharchive.vuw.ac.nz/handle/10063/1202.

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