Systems thinking and regulatory governance

A review of the international academic literature

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State of the Art in Regulatory Governance Research Paper 2020.04

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Abstract

This research paper presents findings from a broad scoping of the international academic literature on the use of systems thinking and systems science in regulatory governance and practice. It builds on a systematic review of peer-reviewed articles published in the top 15 journals for regulatory scholarship. The aim of the research paper is to introduce those working in a regulatory environment to the key concepts of systems thinking and systems science, and to discuss the state of the art of regulatory knowledge on these topics. It addresses five themes: (1) the evolution of systems thinking, (2) examples of systems thinking from the academic literature, (3) evidence of how systems thinking helps improving regulatory governance, and (4) the epistemic challenges and (5) ethical challenges that come with applying systems thinking to regulatory governance and practice.

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1 Introduction

Examples of government-led regulation failing to achieve its intended goals are common around the world. The more high-profile instances occur when poor-performing regulation and under-regulation result in catastrophe, such as the Dhaka garment factory collapse in 2013 in Bangladesh, the Deepwater Horizon oil spill in 2010 in the USA, or the Global Financial Crisis of 2007-2009. These tragic regulatory failures often led for calls to increase government regulation. But at the same time, many citizens feel that they live in a 'nanny state' where overprotective regulation unduly interferes with personal freedom, and businesses complain of excessive 'red tape' stifling innovation. In addition to these external pressures, governments are forced to navigate internal challenges as well. Often regulatory agencies and personnel lack the resources to deliver regulation (that is, implement, monitor and enforce rules) and they struggle to respond with agility to more creative forms of non-compliance – obeying the letter, but not the spirit, of the law.

Systems thinking, systems science, systems theory

Whether in the face of very public regulatory failures or due to the internal challenges of complex regulatory systems, calls are frequently made for the reform of regulatory systems (European Commission, 2008; New Zealand Productivity Commission, 2014; Obama, 2011; OECD, 2005). However, the outcome of regulation—its design, implementation and enforcement—is often the result of a complex interaction of many elements. Changing just one part of the regulatory system ultimately has little impact on the performance of the regulatory system overall.

Adopting a systemic perspective on regulatory challenges and problems appears to offer a useful way to address these observed deficiencies (Cairney, 2012; Hendry & King, 2015; Listorti et al., 2019; McGee & Jones, 2019; Perez, 2008; Stewart & Ayres, 2001). Systems thinking, systems science and systems theory are a broad class of analytical tools and approaches that aim to map, explore and interrogate the behaviour and outcomes of (complex and/or adaptive) systems (Beer, 1995 [1972]; Checkland, 1999; Luhmann, 2013; Meadows, 2008), and can be used to ameliorate the observed deficiencies of current regulatory models. But how do we bring these theoretical and practical tools and approaches into a context in which they can be applied to regulatory problems? What results have we observed where these tools and approaches have been applied in regulatory scholarship?

Because systems thinking seemingly holds great promise for improving regulatory governance, the Chair in Regulatory Practice was asked to carry out a review of the academic literature on systems thinking as it relates to regulatory practice and governance. This research paper presents the main findings of a systematic review of articles published in the top 15 journals for regulatory scholarship. The aim of the paper is to introduce to those working in a regulatory environment the key concepts of systems thinking and systems science, and to discuss the present state of regulatory knowledge on these topics.

Thinking in and of regulatory systems in New Zealand and elsewhere

Since 2000, the term 'regulatory system' has been used over 1,300 times in New Zealand newspapers.[1] Among the more expressive uses are the Waikato Times headline, "Commission slams regulatory

[1] Source: data from a search for the term "regulatory system" in the Newztext Newspapers database on www.knowledge-basket.co.nz, a database of New Zealand newspapers (accessed 16 December 2019).

system" (14 March 2014); the Dominion Post's headline, "Report a damning indictment of regulatory system" (12 March 2012); and the National Business Review's headline, "Offputting rules: Regulatory system deters foreign investors" (23 May 2008).

In that same period, that same term was used over 13,000 times in newspapers across Australia, Canada and the USA.[2] The most notable ones include Barack Obama's contribution to the New York Times titled, "Toward a 21st-Century Regulatory System" (18 January 2011); and the almost poetic Edmonton Journal headline, "Jet-setting celebrities trying to hijack regulatory system, resources minister says" (9 January 2012).

Given how often the term is used in the daily news, it appears that thinking in and of regulatory systems comes naturally to people. But what people—and the organisations they represent—mean by *regulatory system* is often unclear. The headlines from New Zealand cited illustrate that the implied meanings by these titles span the spectrum, from globalized systems all the way down to the local level. For example, the first referenced article refers to the 2014 Productivity Commission's review of regulatory system of New Zealand as a whole. The second aims to sum up the findings of the Royal Commission on the Pike River Coal Mine Tragedy presented in its 2012 report. The third refers to the various regulators and regulations international investors face when doing business in New Zealand.

The other two headlines also show different levels of scale: Barack Obama discusses legislative changes that affect how regulation should be developed, implemented and assessed in the United States (macro scale); the Edmonton Journal refers to resource development, and particularly a large oil pipeline that would connect the Alberta oilsands with the west coast of Canada (micro scale).

Different scales, different topics, different elements

This variance in scale is not limited only to discussions regarding regulatory systems. Often, this variance is evident in the conceptualisation of regulatory systems as well. Take for example the Productivity Commission: "New Zealand's regulatory system includes the institutions, principles and processes through which regulations are made, implemented, enforced and reviewed. It involves all three arms of government – the Executive, Parliament and the Judiciary" (New Zealand Productivity Commission, 2014, 2). This is a very broad conceptualisation of the regulatory system that applies to New Zealand as a whole, bringing together all activities related to regulation, and including all guiding principles that apply to regulatory activity.

Others, however, have a different understanding. The New Zealand Treasury's regulatory system "is a set of rules, norms and sanctions, supported by the actions and practices of designated agencies, to shape people's behaviour in pursuit of a broad policy goal or outcome" (New Zealand Treasury, 2017, 5). Thus, there is a possibility of multiple regulatory systems, their aim is to shape behaviour, and they are bound by the jurisdictions of agencies.

Indeed, many regulatory agencies and entities in New Zealand consider their regulatory systems bound by a broad but finite policy area or topic. For example, MBIE considers itself a "steward of 17 regulatory systems," including the "consumer and commercial regulatory system," which "regulates the interactions that businesses and consumers have before, during, and after the point of sale of a good or service" (MBIE, 2017, 3).

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[2] Source: data from a search for the term "regulatory system" in the News & Newspaper database on www.proquest.com, a database of international newspapers (accessed 16 December 2019).

Sometimes, however, regulators put much narrower boundaries around their regulatory regimes and limit themselves to very specific regulatory functions. The Department of Internal Affairs "private security personnel and investigators regulatory system," for example, is a "licensing and enforcement system for employers and employees" in the private security and investigation industry, and requires "certain license holders to undergo specified training." It "ensures that security personnel are of good character and properly trained" (NZ Department of Internal Affairs, 2018, 1).

One way of thinking in and of regulatory systems: systematic reductionism

Although we see different conceptualisations of regulatory systems across the New Zealand government and elsewhere, many conceptualisations have one thing in common: regulatory systems are envisaged as a set of parts (eg. people, rules, processes, resources) that interact within the boundaries of a finite area or topic (eg. New Zealand as a whole, business transactions, private security personnel) seeking to influence that area or topic within the limitations of politics, the economy, and the judiciary.

We can sum up this view of regulatory systems as 'systematic'; governments tend to view systems according to their constituent parts in order to manage them (Geyer & Rihani, 2010). By understanding and managing the parts, governments seek to create order and a certain level of predictability of the whole. This follows from the belief that by optimising the parts individually, the whole will necessarily be optimised - for example, employing highly specialised staff for within each part.

Indeed, in New Zealand and elsewhere, we see various approaches to optimise all aspects of regulatory governance - development, delivery, and reform of regulation. For example, risk governance and risk-based regulation guide the allocation of scare regulatory resources (van der Heijden, 2019b). Others rely on the insights from the behavioural sciences help educate individuals to make better regulatory choices (van der Heijden, 2019a). While still others employ a model of responsive regulation and enforcement pyramids to achieve better compliance outcomes (Ayres & Braithwaite, 1992; Gunningham & Grabosky, 1998).

In short, the systematic reductionist view of regulatory systems seeks to understand the parts in order to appreciate the whole, with the aim of optimising the parts in order to optimise the whole.

Another way of thinking in and of regulatory systems: systemic holism

There are, however, other methods of systems thinking that may be more helpful in improving regulatory governance. One would be a holistic and systemic understanding of systems.

A systemic view embraces the idea that a system is a set of interconnected parts that, over time, produces a unique pattern of behaviour. A systemic view embraces the idea that the performance of the whole cannot be reduced to the performance of the individual parts. This view embraces the idea that the performance of the part, and their optimisation, may result in an overall change to the whole that is not desired (Meadows, 2008).

Since the mid-20th Century, this systemic and holistic approach to thinking of and in systems has begun to question the systematic and reductionist approach in a range of scientific disciplines. This view questions traditional assumptions of order and the stability of systems; of our ability to predict the outcomes of systems; and of the manageability of systems behaviour. The systemic approach is particularly interested in the dynamics and complexity of systems as a whole, and the extent to which people can understand and, perhaps within limits, influence these dynamics and this complexity.

This systemic and holistic view of systems may help us better understand regulatory systems as well as help us better understand why many well-intended systematic and reductionist optimisations of regulatory systems often do not achieve their desired results at the systems level.

Conceptual boundaries and roadmap of this paper

It is not easy to succinctly summarize the meta-narrative discussions regarding regulatory systems. In this paper the central focus is to study and understand regulation through the various holistic and systemic lenses provided by systems thinking.[3] We will explore several ways of conceptualising regulation as complex, adaptive systems. However, it should be kept in mind that none of the approaches presented herein is dominant or necessarily the 'best' way of thinking in systems.

With this in mind, let us now turn to the problem that systems thinking seeks to address: to what extent and in what way can the complexity of the world be mapped, explored, and analysed? The chapters that follow touch on the evolution of systems thinking, systems science and systems theory (Chapter 2); examples of systems thinking applied to regulatory governance (Chapter 3); evidence of how systems thinking helps improving regulatory governance (Chapter 4—spoiler alert: there is very little application of systems thinking in the academic regulatory literature); and the ethical and epistemic challenges that come with this applying systems thinking to regulatory governance and practice (Chapter 5). Each chapter discusses key insights from the literature, and in the final chapter (Chapter 6) conclusions are drawn from the full review.

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[3] As will become clear through the research paper, systems thinking is substantially different from the tradition of using policy (sub)systems as units of analysis in public policy and political science scholarship (Dupuy & Thoenig, 1979; Howlett & Ramesh, 1998; Jenkins-Smith, St. Clair, & Woods, 1991). The notion of (sub)systems touches on the observation that "certain policy problems brought together groups of [people] from across different branches of government, agencies, and interest groups. They were united in concern about a specific issue and the way it should be handled on the national policy stage" (McGee & Jones, 2019, S140).

2 The evolution of systems thinking

Capturing the evolution of systems thinking and systems science is all but easy. Conventional (scientific) methods for unpacking and understanding historical developments often fall short of capturing the non-linear emergence of different worldviews and feedback mechanisms that have affected the strains of systems thinking over the last century. However all these aspects are central to systems thinking, as this chapter will make clear.

This chapter presents a chronological overview of the evolution of systems. Despite the abovementioned shortcomings, a chronological overview provides a helpful structure for mapping some of the key developments in systems thinking that have relevance for regulatory governance (for more extensive 'chronological' discussions, see among others Geyer & Rihani, 2010; Ison, 2017; Luhmann, 2013; Mingers, 2015; Ramage & Shipp, 2009; Sawyer, 2005).

The Cartesian systematic dissecting of complexity

With the development of Western science during the Enlightenment (17th and 18th centuries), scholars became increasingly interested in deductive reasoning and methods. Through René Descartes and his followers, a reductionist view of science made rapid inroads into theory. It replaced the more holistic understandings of how the world operates that dominated pre-Enlightenment science (Russell, 2004 [1946]; Scruton, 1994).

The Cartesian view holds that to understand how things work (to find the 'truth', or to find causality), "the way to proceed was to successively split up entities into their component parts until ultimate components were reached, at which point ultimate explanations were possible" (Mingers, 2015, 29). The sciences have applied this Cartesian reductionist view of systematic dissecting of complexity with great success. It has provided major breakthroughs in areas ranging from astrophysics to molecular physics, and from structural engineering to social engineering.

Nevertheless, the Cartesian view is not without shortcomings. The central assumptions it makes are that: (i) "a component part is the same when separated out as it is when part of a whole" (Checkland, 1999, 12), and (ii) "the whole is the sum of the parts, no more and no less" (Geyer & Rihani, 2010, 13). But by the turn of the 20th century, scholars began to notice that these rules do not always apply (Kuhn, 2012 [1962]).

Scientists studying biological, societal, and other 'living' systems found that this mechanistic, or clockwork, understanding of the world often could not explain why the whole system performed as observed (Eppel & Rhodes, 2018; Guimaraes Pereira & Funtowicz, 2015; Pycroft, 2014). A well-known example is Adam Smith's 'invisible hand' that seeks to explain market equilibrium (Smith, 2003 [1776]): it cannot be reduced to or observed in any individual market participant, but *emerges* at the level of the market as a whole (Miller, 2015).

Early systems thinking: Inquiry into emergence

Emergence is the term used to describe the behaviour of a system as a whole that cannot be observed in or reduced to the component parts of the system (Sawyer, 2005). Emergence is a result of how the component parts of a system relate and interact. Or more formally: "Emergent properties of an entity are properties possessed only by the entity as a whole, not by any of its components or by the simple aggregation of the components" (Mingers, 2015, 30). This philosophical concept is central to systems thinking and logically gets us to a widely acknowledged definition that systems are "complexes of elements standing in interaction" (von Bertalanffy, 1969, 33).

Studying emergence is central to understanding how a system achieves stability (or fails to achieve it) and how it maintains that stability over time (Parsons, 2012 [1951]). In the first half of the 20th century, scholars have been quite successful in studying emergence in closed systems (systems in which no elements enter or leave the system). However, it quickly became clear that most living systems, such as society and its (sub)systems, are *open systems* (von Bertalanffy, 1969); systems where elements (eg. information, people, resources, excess) flow between the system and its environment. (Nobles & Schiff, 2004; Ramage & Shipp, 2009).

With the insight that most living systems are open systems, scholars increasingly began to include the impact of a system's environment on the system's behaviour, and they became particularly interested in understanding the boundaries between system and environment. To speak with one of the central figures in the systems thinking literature, Niklas Luhmann: *Systems have boundaries. This is what distinguishes the concept of system from that of structure… [A] boundary separates elements, but not necessarily relations. It separates events, but lets causal effects pass through… Boundaries can be differentiated as specific mechanisms with the specific purpose of separating yet connecting (Luhmann, 1995, 28-29).*

Another element of great interest is that of stability and change within open systems (Pycroft, 2014). Because of their characteristics, open systems are likely to be in a state of *dynamic equilibrium* (ebb and flow) rather than steady or fixed equilibrium (a characteristic of closed systems). A system that is in dynamic equilibrium can (sometimes easily and sometimes quickly) be pushed out of balance by elements within or outside the system. Given the dynamic nature of open systems, small changes in the elements of a system or its environment may affect the overall behaviour of the system in unexpected ways (Ramage & Shipp, 2009). In other words, open systems often show *nonlinear* behaviour in which "a small change in initial conditions can lead to a radical change in a later state of the system … or, inversely, a large change in initial conditions might not lead to any significant change in later states of the system" (Sawyer, 2005, 16). Non-linear behaviour cannot be explained by the behaviour of the individual elements of a system (Dekkers, 2015).

Further advancements: Inquiry into functionally different societal systems

Open systems thinking also acknowledges that the environment of one system is often another system or even a set of other systems: "Every change in a system is a change in the environment of other systems; every increase in the complexity in one place increases the complexity of the environment for all other systems" (Luhmann, 1995). This insight raises a range of other questions, as illustrated by the work of Niklas Luhmann and his impact on (socio-)legal theory (Luhmann, 1995, 2004, 2013).

Luhmann observed that since the 19th century society has become functionally differentiated. In Luhmann's view, a multiverse of 'function systems,' such as law, economy, politics, religion, and science, now operate side by side, having replaced previously stratified societal structures in which characteristics such as class, family and region were fundamental. All function systems have a unique mode of communication and logic, and one single system cannot replace, coordinate, or dominate the other. For example, the economic system uses money as its mode of communication and seeks to ease the transfer or movement of goods and services, but it cannot replace the function of law which established the legality of ownership of those goods and services. Each of these function systems operates with a specific set of binary codes that reduces the complexity within the system. The legal system uses the binary coding of legal/illegal; the science system uses true/false; the economic system uses profitable/non-profitable, and so on. The differences between *function* and *coding* in these systems result in challenges. For example, translating the legal coding of legal/illegal to the science coding of true/false or the economic coding of profitable/non-profitable is difficult.

Luhmann and scholars building on his work (for example, Teubner, 1997, 2001) conceptualise these function systems as self-producing, autonomous and self-referential—or *autopoietic* (for extensive discussions, see Dekkers, 2015; Mingers, 2015; Perez, 2008). The notion of autopoiesis is relevant for at least two reasons: One, because of their internal logic and modes of communication, social systems and subsystems are very difficult influence with rules external to those systems (Burns & Flam, 1987; Luhmann, 1995). Two, systems are considered circular because the rules (including penalties and rewards) that steer the behaviour of a system are produced and reproduced by that system—thus, durable systems are capable of keeping internal mutations and external enactment at bay (Dekkers, 2015; Mingers, 2015).

Of the different strains of systems thinking discussed in this chapter, Luhmann's is certainly not the easiest to grasp (for highly accessible introductions, see King & Thornhill, 2003; Nobles & Schiff, 2004, 2013). Still, scholars observe that the work of Luhmann and those expounding on his earlier observations are especially relevant to modern regulatory governance (Brans & Rossbach, 1997; Dekkers, 2015; Perez, 2011). The concepts of system-specific communication, logic and coding, may help to understand better why certain state-led regulatory interventions fail, for example, when they encounter "trans-systemic incompatibilities" (Perez, 2008, 291); or succeed when they allow for "structural coupling" of systems, overcoming the challenges in logic, coding and language used between different systems (Luhmann, 2013; Nobles & Schiff, 2013). Many of these scholars argue for acknowledging that state-led regulation is unable to steer society's functional systems, and at best can be used to establish general rules (*'meta-regulation'*) for reducing and resolving the trans-systemic incompatibilities of logic and coding (Burns & Flam, 1987; Kooiman & van Vliet, 2000; Simon, 2017).

Parallel and later systems thinking: Inquiry into stocks, flows and feedback loops

Advances in cybernetics, the study of communication and automated control, strongly influenced the work of Luhmann and his followers (Luhmann, 2013; Mingers, 2015). Other strains of open systems thinking also have their roots in cybernetics but have evolved in a slightly different direction. Notable examples include Donella Meadows (2008) and Peter Senge. To Meadows and Senge, systems thinking is helpful to understand why some systems achieve (dynamic) equilibrium and others do not, and how we might have some influence on the behaviour of systems. In Meadow's words, "System thinkers see the world as a collection of stocks along with the mechanisms for regulating the levels in stocks by manipulating flows" (Meadows, 2008, 25).

In this model of systems thinking, the role of *feedback* is of central importance (Dekkers, 2015; Haynes, 2018; Ramage & Shipp, 2009). Feedback is not necessary for a system to exist, but it is essential for it to adapt and flourish (Von Bertalanffy, 1967). Scholars often distinguish between two broad feedback mechanisms. The first is *balancing or stabilising feedback* (sometimes referred to as negative feedback). This form of feedback aims to direct the system towards equilibrium by correcting for imbalances. For example, if the level (stock) of noncompliance with regulation goes up (flow) in a sector, the responsible regulatory agency may provide feedback in the form of decision to increase the number of its inspections; increase the stringency of inspections; increase the number of fines issued; or increase the severity of fines.

The second form of feedback is *reinforcing or amplifying feedback* (sometimes referred to as positive feedback). For example, the changed perception about compliance-costs in a sector may result in firms seeking to cut corners, which may ultimately result in an increased level of noncompliance in the sector. This may further change perceptions about compliance-costs, causing more firms to cut corners, resulting in even higher levels of noncompliance. Positive feedback causes imbalance in the system and is often the cause of too much outflow or inflow, though sometimes this form of feedback is desireable. Mapping the various stocks, flows and feedback loops of a complex system can give tremendous insight into the dynamics of that system (Meadows, 2008; Senge, 2006).

Systems often show highly complex or competing forms of feedback having a nonlinear, and sometimes circular, impact on the stability of the system as a whole (Pycroft, 2014; Ramage & Shipp, 2009). The difficulty then is to limit the impact of unwanted reinforcing or amplifying destabilizing feedback. Systems scholars are particularly vocal about the risk of *time-delays* that decisionmakers face when seeking to influence feedback loops (Meadows, 2008; Stroh, 2015). Any intervention needs time to achieve its desired effect, and further instability is likely when the intervention is not given time or is too vigorous to begin with. "Aggressive action often produces exactly the opposite of what is intended. It produces instability and oscillation, instead of moving you more quickly towards your goal" (Senge, 2006, 91).

Other advancements: Questioning the (ontological) reality of systems

By the end of the 20th century, systems thinking had become an accepted approach for studying complexity, dynamics, and adaptation in various areas of society. At the same time, some scholars became critical to the notion of systems as 'something existing out there' (Archer, 2003; Giddens, 1984) and the limits of systems thinking faced in the 'engineering' of solutions for societal problems (Checkland, 1999; Sawyer, 2005). In response, a new strain of systems thinking emerged that considers systems as heuristic devises that help to study the world, but do not exist in the world (Ison, 2017; Mingers, 2015). This strain is often captured under the notion of *soft systems thinking*. Here 'soft' is not (only) meant to mean 'societal' or 'human,' but also to indicate that the problems systems thinking seeks to address are often unstructured and ill-defined (Wilson & van Haperen, 2015).

Central research themes in this strain of systems thinking are the *reflexivity* of humans and the different *worldviews* (the different meanings and senses that people bestow upon the systems they are part of) that individuals hold (Warren, Sauser, & Nowicki, 2019; Wilson & van Haperen, 2015). Because social systems are "characterized by self-reflecting agents who try to understand the social systems they themselves are in" these soft systems lack the predictability of technical and mechanical systems (Teisman & Klijn, 2008, 290). Adherents to this model are particularly critical of attempts to model social systems by using a 'representative agent' approach—as is often done in, for example, economic cost-benefit analyses (Eppel & Rhodes, 2018; Sawyer, 2005; Watts, 2011).

Stafford Beer (1995 [1972]) and Peter Checkland (1999) are central figures in this school of systems thinking. Checkland maintains that approaching systems thinking in this manner is helpful because it allows for "modelling purposeful 'human activity systems' as sets of linked activities which together could exhibit the emergent property of purposefulness" (Checkland, 1999, A7). Looking at systems in this manner allows, at the very least, for learning *why* a specific behaviour or outcome emerged in a (human activity) system, and could possibly present an opportunity to steer emergent behaviour or outcome towards a desirable state (Beer, 1995 [1972]). This strain of systems thinking acknowledges "that the nature of the problem cannot be understood separately from its solution. Policy responses cannot therefore be 'designed', but represent a way of navigating through the problem" (Stewart & Ayres, 2001, 83). Approaches such as the *Soft Systems Methodology* (Warren et al., 2019; Wilson & van Haperen, 2015) and the *Viable System Model* (Espejo & Reyes, 2011; Hoverstadt, 2008) provide tools to map, explore, and interrogate (social) processes and organisations ('systems'), and work towards improving them (see the next chapter for an example).

A related strain of soft systems thinking seeks to bridge these insights with earlier paradigms. *Conscious systems thinking* embraces notions of partial order ("phenomena can exhibit both orderly and chaotic behaviours"); reductionism and holism ("some phenomena are reducible others are not"); probabilistic modelling ("there are general boundaries to most phenomena, but within these boundaries exact outcomes are uncertain"); emergence (phenomena "exhibit elements of adaptation and emergence"); and interpretation and reflexivity ("the actors in the system can be aware of themselves, the system and their history and may strive to interpret and direct themselves and the system", Geyer & Rihani, 2010, 29).

Summing up: The relevance of systems thinking for regulatory governance and practice

This chronological overview has scratched the surface of the rich systems thinking literature and science that have emerged over the last hundred years or so. The aim of this overview was to indicate (i) how different strains of systems thinking have relevance for regulatory governance and practice in highly varied ways, and (ii) the central concepts of systems thinking that recur across these strains. This brief history of systems theory demonstrates that systems thinking is not static, nor is it a single approach to reducing the regulatory complexity we see around us.

Thinking in systems can mean many things when applying it to regulatory governance and practice: regulation 'as' systems, regulation 'of' systems, regulation 'through' systems, regulation 'in' systems, regulation 'between' systems, and so on. Systems thinking gives the tools and concepts to look at regulation in a systematic and systemic matter—that is, to look at the parts and to see the whole. Likewise, it helps to think about regulation as being complicated and complex, and sometimes both. Often regulation is made up of many parts that influence the outcome in a predictable a linear manner, but sometimes the outcome emerges in an unpredictable and non-linear manner.

Equally important, systems thinking helps to analyse regulatory governance and practice in novel ways. Thinking about society as having functionally different systems requires us to consider what language or coding will resonate with those we seek to target through regulation. Thinking about regulation as a system of stocks and flows requires us to consider the risks of oscillation that may result from a specific regulatory intervention. Thinking about systems as a heuristic tool requires us to be modest in what we can achieve through regulatory reform and accept that sometimes we can only learn how to do better a next time (Beer, 1995 [1972]).

Embracing systems thinking as a tool for regulatory governance and practice in this manner also fits well with very recent developments in systems thinking (Geyer & Rihani, 2010; Sawyer, 2005). These hold that we should not radically distinguish between order or chaos, but rather think in terms of partial order. Sometimes phenomena are complex and show nonlinearity, and sometimes they are merely complicated yet predictable. In regulatory governance and practice, there likely is room for 'old school' reductionism coupled with more recent holism as practised in systems thinking. In the chapters that follow, examples will be given of what is considered the current prevailing approach while acknowledging that, over time, even this will change.

3 Examples of systems thinking in regulatory scholarship

Inspired by the insights of systems thinking, scholars around the world have begun to apply systems thinking to their inquiries into regulatory governance and practice. This chapter looks at some examples of how scholars have applied systems thinking in the study of regulations.

Regulation as systems of stocks and flows, nonlinearity, dynamics and feedback

In his book *Outbreak: Foodborne Illness and the Struggle for Food Safety* (2019), author Timothy Lytton seeks to better understand the interaction of government regulation, civil liability and private governance in the field of food safety regulation. The book carefully unpacks the complex system of food safety regulation in the USA. Many of Lytton's ideas draw their insight from the work of systems thinkers such as Donella Meadows.

The book opens with the account of a 2011 listeriosis outbreak in the United States. At the time, it was the worst foodborne illness outbreak since the U.S. Centre for Disease Control and Prevention began tracking outbreaks in the 1970s. The case resulted in 33 deaths and a total of 147 confirmed cases. The origins of the outbreak were traced back to a cantaloupe farm. However, after carefully laying out the details of case, Lytton makes an insightful conclusion regarding the true cause of the outbreak: "No one seems entirely to blame, yet everyone seems partially at fault" (Lytton, 2019, 20).

In the specific Listeria case, and in other examples cited by Lytton, it was the *interplay* of a range of individuals and organisations, laws and regulations, interpretations and customs, and various forms of (failed) stabilising and (unfortunate) reinforcing feedback loops that best explained the full scale of the outbreak. Because of the complexity of the food system, the initial outbreak at the cantaloupe farm developed quickly in a nonlinear manner, ultimately affecting 28 states across the USA.

After discussing several related cases, Lytton further illustrates how the concepts and language of systems thinking help to analyse these cases. More importantly, it helps Lytton point out patterns connecting all the cases, like a common thread. In the end, Lytton calls for systemic regulatory reforms that aim to improve system learning and feedback mechanisms within the food safety regulatory system.

Regulation in a functionally differentiated society

In her book *Meta-regulation in practice: Beyond normative views of morality and rationality* (2017), author Fiona Simon applies Niklas Luhmann's systems theory in another critical industry. Simon seeks to understand better how meta-regulation (here understood as government regulation of industry self-regulation) has played-out over seventeen years in the Australian retail energy industry.

Simon challenges the assumption that meta-regulation is a "progressive policy design that works effectively with markets and promotes stakeholder inclusion in order to reach a more informed view of the public interest and how the public interest can be met by business" (Simon, 2017, 4). While not everyone will agree with Simon's interpretation of meta-regulation, it is worthwhile to challenge the broader assumption that the involvement of a variety of stakeholders in regulatory design and implementation will yield optimal regulatory outcomes.

Building on Luhmann's systems theory, Simon argues that exactly the opposite seems to have happened in the Australian retail energy industry. According to Simon, the three main function systems in the retail energy industry (the Australian political, economic, and legal systems) have difficulty communicating with each other; or, at the very least, they do not speak each other's language. For example, energy providers operate within the economic system and they see events strictly in terms of profitability vs. loss. The values and language of the political and economic system do not resonate with them, and vice versa.

To Simon, it is therefore not too surprising that meta-regulation of the Australian energy retail industry has not resulted in positive outcomes because it does not speak the 'language' of the main players. Energy experts are assumed to understand legal arguments, and regulators, often operating under political pressure, are rebuffed for their lack of appreciation for the nuances of operating a company within the energy market. The result is a regulatory system undermined by too much miscommunication and misunderstanding. According to Simon and her application of Luhmann's systems theory, it is a recipe for "messy regulatory outcomes" (Simon, 2017, 30).

Regulation and (contemporary) cybernetics: Algorithmic regulation

The link between cybernetics, the study of control and communication in mechanic and living systems, and regulation is a symbiotic one. Central to cybernetics is the algorithm, "a technique, or a mechanism, which prescribes how to reach a fully specified goal" (Beer, 1995 [1972], 52). Algorithms are sequences of well-defined instructions for solving a problem (Peters, 2012) which is why algorithms (and cybernetics) complement how regulation is sometimes conceptualised (Freiberg, 2010; Hood, 1983).

The growth of information technology and, in particular, big data has resulted in a renewed interest in cybernetics for regulatory governance. In 2019, renown regulatory scholars Karen Yeung and Martin Lodge published an edited volume titled, *Algorithmic Regulation.* Algorithmic regulation is understood "both as a means of coordinating and regulating social action and decision-making, as well as the need for institutional mechanisms through which the power of algorithms and algorithmic systems might themselves be regulated" (Yeung & Lodge, 2019, back cover). The authors are mainly interested in exploring the use of big data, information technology, and computer algorithms to support regulatory governance and practice. Various chapters, for example, discuss the opportunities and constraints of machine learning and artificial intelligence (AI) as tools for regulatory and enforcement decision-making.

Of course, the notion of algorithmic regulation could also be conceptualised at a more abstract level. As Tim O'Reilly, a central figure in open source software, argues: regulation could be "regarded in much the same way that programmers regard their code and algorithms, that is, as a constantly updated toolset to achieve the outcomes specified in the laws" (O'Reilly, 2013, 291). In this sense, algorithmic regulation implies ongoing monitoring and modification of regulatory governance practice and goals through feedback of regulation performance in real-time.

Yet, because the goal of regulation often cannot be specified in minute detail, algorithms need to be complemented with heuristics, as explained by Stafford Beer: *An heuristic will take us to a goal we can specify but do not know, and perhaps cannot even recognize when we reach it. The algorithm (such as: 'to get to the highest point, try one step in each direction, and move to the next higher position') specifying this heuristic stipulates the eventual discovery of a strategy. The strategy says: 'The best thing to do is to go up here for so far, round this, along that, then up the other.' This strategy cannot be worked out in advance* (Beer, 1995 [1972], 54-55).

Regulation and the Soft Systems Methodology

Practical applications from soft systems thinking and second-order cybernetics, such Soft Systems Methodology (SSM) and the Viable Systems Model, have seen little application in regulatory governance and practice (Schwaninger & Scheef, 2016; Warren et al., 2019). An insightful book that illustrates how the SSM could help to improve regulatory governance and practice is Brian Wilson and Kees van Happeren's *Soft Systems Thinking, Methodology and the Management of Change* (2015), which presents case studies of the SSM in areas of service delivery and risk management—all closely related to regulatory governance and practice.

SSM requires a careful understanding and defining of the system at hand—known as 'root definition'. Defining the system and the problem it seeks to address is best done by a variety of individuals and organisations from within the system. In short, the definition includes the basic transformation a system seeks to achieve (T), the worldview that provides meaning to this transformation (W), system ownership (O), system operators (A), the customer or target of the system (C), and the environmental constraints of the system (E).

In the case of law enforcement, or a local police department for instance, a root definition could be: *A chief constable owned system [O], operated by appropriately skilled police officers and other agencies [A], to establish community [C] well-being in terms of the security of people and property [T], by seeking to prevent unlawful and antisocial activity, together with other potential disruptions, responding to reported incidents and identifying and apprehending those who violate the law and delivering them to the appropriate judicial authorities [W], while acting within the accepted norms of behaviour and visibility requirements, but constrained by finance availability, Home Office and local policies [E]* (Wilson & van Haperen, 2015, 23).

After establishing the root definition—again, done in a deliberative process with a variety of individuals and organisations from within the system—conceptual models are developed to actualize the stated aims (C). These conceptual models then must be compared with the real-time, real-world situation to define possible and feasible changes.

Summing up

This chapter has put some meat on the theoretical bones of systems thinking and systems science presented in Chapter 2. Over the last decade, several books have been published that apply systems thinking to regulatory problems. These books seek to map, explore and interrogate regulatory problems. Sometimes they also provide solutions to regulatory problems. However, none of the books provide evidence that systems thinking applied to regulatory governance and practice will result in better regulatory outcomes. In the chapter that follows, we will zoom-in further and explore the evidence and findings that have resulted from systems thinking in regulatory scholarship.

4 Evidence and findings from systems thinking in regulatory scholarship

We now have a good understanding of the breadth and depth of systems thinking and the contribution it can make to regulatory governance and practice. It is therefore time to ask the hard question: *does systems thinking result in better regulatory governance and practice?*

It is a difficult question and one that is not easily answered. This research paper builds on a systematic review of the application of systems thinking in peer-reviewed articles from the top 15 journals published in the second half of 2019 for regulatory scholarship (see, further, Appendix B). The review identified 637 articles mentioning systems thinking concepts and terminology. However, only nine articles were identified as explicitly engaging with the ideas and concepts from systems thinking literature. All of these articles were written by scholars from Western countries and presented examples from Western countries.

In sum, when looking at the full set of articles reviewed, it becomes clear that systems thinking terminology is frequently mentioned by regulatory scholars, but often in passing or as a vaguely defined umbrella term. Systems thinking has seen very little *application* in regulatory scholarship, and a very large part of the world is under-represented in the scholarly debate.[4] The following sections present findings from these nine articles clustered by the strain of systems thinking they apply.

Findings on regulation in a functionally differentiated society

The work of Niklas Luhmann (who promotes the idea that society consists of functionally differentiated systems with their own logic and language) is the most commonly cited scholar in the articles reviewed. Seven of the nine articles identified take inspiration from Luhmann's theory of systems thinking (Aalders & Wilthagen, 1997; Born & Goldschmidt, 1997; Cohn, 2001; Lawson, 2011; Perez, 2008; Sargent, 2015; Verschraegen, 2018). These articles address three specific themes that can broadly be summarised as: "To regulate is to perform a social act of intentional communication" (Born & Goldschmidt, 1997, 26).

First, scholars illustrate how miscommunication between systems may result in noncompliance and regulatory failure. The binary code of law often does not allow for capturing the nuanced and often fuzzy reality that regulators face (Sargent, 2015). Noncompliance can be expected when the rational-legal language and concepts used in law and in regulation do not reflect or resonate with those used in the economic, environmental, or societal areas they seek to address (Aalders & Wilthagen, 1997; Born & Goldschmidt, 1997). Such noncompliance is systemic rather than merely an unwillingness to comply on the part of regulatees. A typical example is 'creative compliance' when regulatees comply to the letter but not the intention or spirit of the law (Cohn, 2001).

Second, scholars use this strain of systems thinking to illustrate the limits of external, state-led regulatory governance to regulate various areas of society (Perez, 2008). Function systems such as the economy, science, and religion, as well as their subsystems such as market areas and firms, come with an inherent internal logic, objectives, structure, culture, rewards, punishments, and criteria to establish expertise. Law and regulation are unable to determine and directly steer the activities of

[4] Likewise, others have concluded that systems thinking and systems science has seen very little application in academic studies of public policy and administration (see, for example, Dekkers, 2015; Eppel & Rhodes, 2018; Klijn, 2008).

these systems because it cannot specify the form and interpretation of all relevant aspects. Therefore, according to these scholars, regulatory governance can only – at best – negotiate and influence the self-reglatory tendencies and processes in the various areas of society (Aalders & Wilthagen, 1997; Verschraegen, 2018).

Third, scholars stress the role of regulation, regulatory agencies, and regulatory practitioners in bridging the various functional systems and subsystems of society. Regulation allows for embracing the fuzziness of human interactions and transactions, and help finding alternative paths towards compliance and legality—both in the drafting of regulation (Cohn, 2001) and in day-to-day regulatory practice (Aalders & Wilthagen, 1997). Also, regulation can help to create jargon, concepts, and tools to bridge those of different (sub)systems with those of the legal system. For example, licensing a firm's internal self-regulatory regime bridges the logic of the economic system and the logic of the legal system. For the regulator, the question then is not about distinguishing between profitable/nonprofitable (as a firm would do) or legal/illegal (as a lawyer would do), but according to the standard of acceptance/rejection of the firm's self-regulatory regime (Lawson, 2011).

Findings on regulation as a (cybernetic) system of control

The other strains of systems thinking discussed in Chapter 2 of this paper have seen very limited application within the pages of the 15 top journals for regulatory scholarship. One of the remaining two articles, written by Karen Yeung, discusses the notion of algorithmic regulation.

In her article, Yeung does not provide findings or evidence of how algorithmic regulation has improved regulatory governance and practice. Instead, Yeung presents a taxonomy of eight different forms of algorithmic systems "based on how these systems are configured in relation to each of the three components of a cybernetic system: that is, at the level of standard-setting (whether behavioural standards are "simple"/fixed or "complex"/adaptive), information gathering and monitoring (reactive or pre-emptive), and behaviour modification (automated or recommender systems)" (Yeung, 2018, 518).

The article is a valuable read for those interested in the use of big data and information technology in regulatory governance. Yeung maps a range of debates in this area and discusses concerns about the legitimacy of algorithmic regulation, its accountability, redistributive powers, ideologies, authority, and its capacity to affect the lives of individual citizens. Strictly speaking, however, the article does not provide evidence of how systems thinking has helped or hindered regulatory practice in a real-world situation.

Findings on regulation as systems of stocks and flows, nonlinearity, dynamics and feedback

The final article identified and reviewed assesses the use of systems dynamic computer modelling in analysing potential outcomes of regulation. Systems dynamic computer modelling builds on central ideas from systems thinking such as stocks and flows, nonlinearity, dynamics, and feedback. This article discusses the impact of an HIV testing law and related regulation in New York (Martin et al., 2015). While this was the only systems modelling article found in the top 15 journals for regulatory scholarship, regulatory governance and practice examples sometimes appear in more specialised modelling journals (e.g., Arango, 2007; Carden, Goode, Read, & Salmon, 2019).

Systems dynamic computer modelling allows for exploring different implementation scenarios to prepare for different 'what-if' outcomes. For example, this particular study found that under different implementation scenarios the initial surge of newly diagnosed HIV cases would differ, but in the long run all scenarios resulted in roughly similar patterns. Such knowledge is useful in the planning and budgeting stages, by helping regulators anticipate when and how much trained staff is required over the different stages of implementation.

Moreover, by comparing various possible testing regulations, it became clear that specific indicators were better predictors for and representations of the performance of the HIV testing law and regulation than others. This insight is relevant because the model helps decisionmakers and frontline workers understand what condition(s) to monitor closely. Keep in mind, because of nonlinearity and dynamics, a small change in a condition may have a big impact over time. It is therefore helpful to know what conditions may trigger such non-linear behaviour.

Take home lessons for regulatory policymakers and practitioners

The findings summarised here are insightful, but they fall short in addressing pressing questions of *what* forms of systems thinking help improve regulatory governance and practice, and *where* and *why* those forms are most insightful. Scholars are highly interested in systems thinking and systems science as an approach to study regulatory delivery, but to-date not much empirical research has been carried out. Despite all the calls for ‘thinking in systems’ by regulatory agencies and those assessing regulatory agencies, we have little evidence that thinking in systems will improve regulatory performance.

In addition, committing to systems thinking should not be done light-heartedly. Carrying out a systems analysis of regulatory governance requires a substantial investment of time and resources. Deciding on what systems thinking strain to follow will be equally time and resource intensive. However, without taking these steps seriously there seems to be little point in applying systems thinking to a regulatory problem.

5 Epistemic and ethical challenges

Like any approach to regulatory governance, systems thinking presents epistemic and ethical challenges. What is the minimal knowledge required for 'good' systems analysis of regulatory governance and practice? Who decides how much knowledge is enough for such an analysis, and who chooses the 'right' strain of systems thinking to follow? In this chapter, we will discuss the epistemic and ethical challenges of systems thinking applied to regulatory governance and practice.

The epistemic challenges of systems thinking in regulatory governance

Many of the epistemic challenges discussed in the literature address the differences in and limits to knowing what constitutes a system and how best to conceptualise it. The challenges broadly revolve around two questions: is thinking in systems possible at all, and what knowledge is needed to change a system?

Is thinking in systems possible at all?

We have already seen that systems thinking makes a clear distinction between systematic thinking and systemic thinking (Churchman, 1971; von Bertalanffy, 1969). Systemic thinking takes as a starting point that the behaviour and performance of the system *emerge* from its constituent parts. To understand emergent-properties of the system, its constituent parts and their relations need to be understood—including feedback and non-linearity. Systematic thinking breaks the system down, in a structured manner, into its constituent parts, and then study the parts individually. It assumes that the sum of the insights into the parts will give insight into the behaviour and performance of the whole.

We have also seen that systems thinking makes a clear distinction between complicated systems and complex systems (Meadows, 2008). Complicated systems typically consist of many interrelated constituent parts—sometimes of a highly technical nature. Still, the parts and their interactions show predictable behaviour and can be orchestrated because, in complicated systems, cause and effect operate linearly. However, in complex systems cause-effect relationships are less visible, less predictable, often non-linear, and are therefore less manageable.

Finally, we have seen that there are many ways of thinking in systems, with no single strain being dominant - or the 'best' way (Burns & Flam, 1987; Checkland, 1999; Luhmann, 1995; Meadows, 2008; Senge, 2006). Thinking in and of systems comes quite naturally to people, and our worldviews strongly affect how we think in and of systems (Perez, 2008; Ramage & Shipp, 2009). Which also explains the differences we have seen between thinking of systems as something 'out there'—an *ontological* approach—and systems thinking as a tool that helps us to think about reality—an *epistemological* approach (Sawyer, 2005; Wilson & van Haperen, 2015).

What knowledge is needed to change systems?

A main epistemic challenge for those interested in applying systems thinking to regulatory governance and practice is to embrace the different approaches to systems thinking (Mingers, 2015). That gets us to one of the paradoxes of systems thinking. Systems thinking helps to reduce and give insight into complexity (Eppel, 2017), but systems thinking itself is a highly complex activity. Mapping and analysing systems requires collecting and processing considerable amounts of data and knowledge. So, can such knowledge help us changing the systems we are facing?

Systems thinkers are generally sceptical about our ability to influence the specific behaviour or direction of systems simply by 'knowing' the system. In the words of Stafford Beer, "[i]nstead of trying to organize it in full detail, you organize it only somewhat; you then ride on the dynamics of the system in the direction you want to go" (1995 [1972], 55). Or, to cite Donella Meadows, "one of the most frustrating aspects of systems is that the purposes of subunits may add up to an overall behaviour that no one wants" (Meadows, 2008, 15). Put differently, even if one is capable of knowing all the constituent parts of a system, the system may still be fully out of one's control. Nevertheless, scholars point to various aspects of systems that are relevant to know and understand when seeking to change systems—such as stocks and flows, feedback, time delays, trigger points, and the mode of communication within a system.

The consensus among systems thinkers is that there is little point in just changing one element of a system (Meadows, 2008). The change of a single element in one part of the system will likely trigger an unanticipated change elsewhere (Windholz, 2018). Likewise, a lack of knowledge or data from the system as a whole easily results in unnecessarily forceful or hasty changes and may result in undesired outcomes or oscillation within the system (Senge, 2006; Stroh, 2015). Finally, even when a system appears to be performing well, there still is a risk that it is stuck in a cycle of suboptimal performance (Geyer & Rihani, 2010; Miller, 2015). In such instances, any direct change to the system may result in a worsening of performance in the short term but, in the long run, more optimal performance may be possible. Therefore it is necessary that we engage in ongoing critical assessment of the systems we work in and work with—both those that work well and those that do not.

The ethical challenges of systems thinking in regulatory governance

The ethical challenges discussed in the literature closely relate to these epistemic challenges. The first set of challenges is obvious. Because systems thinking acknowledges and calls for embracing different worldviews and different forms of knowledge, those practising systems thinking will face dilemmas of weighing, balancing, and merging these worldviews and forms of knowledge. It is likely that, at some point in the systems thinking process, a decision must be made to give more weight to some worldviews and forms of knowledge than to others. Yet, doing so gives more power to some in the system while taking it away from others (Ramage & Shipp, 2009; Windholz, 2018).

The second set of ethical challenges considers related choices. Different approaches to systems thinking ask different questions of systems and, thus, provide different solutions to deal with systemic challenges. The initial choice of which approach to follow may result in similar power imbalances as choices over what worldview and forms of knowledge to use. In this way, systems thinking can be easily politicised. Likewise, the initial choice of a specific systems thinking approach will have impact on whether systemic solutions that result from it lean more towards collective or individual welfare, long or short term gains and losses, vested special or general interests, and so on (Martin et al., 2015; Stroh, 2015).

A final set of ethical challenges identified in the literature revolves around the risk that people embrace systems thinking, its jargon and concepts, to justify a *lack* of action to change matters. More problematically, systems thinking can quite easily be abused to absolve oneself or one's organisation from responsibility for a problem. To recap, systems thinking emphasises complex interactions of several parts of a system and how these affect the system's behaviour and performance (Beck, 1992; Burns & Flam, 1987). That, ironically, leaves no individual (or organisation or group) to blame when the system malfunctions, yet everybody partially at fault (Lytton, 2019).

6 Conclusion

This research paper has reviewed a large collection of academic literature on systems thinking and systems science and its application in regulatory governance scholarship. It has addressed the evolution of systems thinking and systems science (Chapter 2); examples of systems thinking applied to regulatory governance and practice (Chapter 3); evidence and findings from systems thinking in regulatory scholarship (Chapter 4); and the ethical and epistemic challenges that come with applying systems thinking to regulatory governance and practice (Chapter 5). Each chapter has discussed key insights from the literature. Three broad conclusions can be drawn from the review.

First, while thinking in and of systems comes naturally to many people, systems thinking (as explored in this research paper) is often difficult work. There is no single approach to systems thinking, nor are there shortcuts for 'quick' systems thinking. Systems thinking is a meta-discipline (Checkland, 1999). A call for applying systems thinking to a regulatory problem is a call to focus on the emergent behaviour of a collection of parts and their interactions as they ostensibly relate to that regulatory problem. A call for systems thinking is not a call for a specific approach to understanding a regulatory problem, nor a call for a specific approach to address it. A call for applying systems thinking to a regulatory problem can just as well be a call for a systematic analysis of a complicated regulatory problem, as a call for a systemic analysis of a complex regulatory problem. Still, as this research paper has indicated, there are broad strains of systems thinking that regulators may wish to follow (or even combine) when calling for systems thinking for or of regulatory governance. To name a few, a regulatory problem may be approached from the 'communicative' systems thinking strain introduced by Luhmann and others, and question whether the logic and language and of (government) regulation resonates with that of the actors and environment it seeks to influence (King & Thornhill, 2003; Luhmann, 2013; Teubner, 1987). Likewise, a regulatory problem may be approached from the 'stocks and flows' systems thinking strain advanced by Meadows, Senge and others, and explore the feedback loops, delays and nonlinearity that affect the regulatory problems (Meadows, 2008; Senge, 2006; Stroh, 2015). Alternatively, a regulatory problem may be approached from the 'soft' systems thinking strain developed by Beer, Checkland and others, and question the human understanding of that very problem itself (Beer, 1995 [1972]; Checkland, 1999; Wilson & van Haperen, 2015).

Second, while systems thinking is often presented as a non-reductionist approach that helps inform understanding about 'the whole', the holism and wholeness that systems thinking aims for should not be conflated with how these terms are understood in other meta-disciplines, or in traditional and indigenous knowledge such as *mātauranga Māori*. At the end of the day, systems thinking as discussed in this research paper aims to simplify complexity, and is interested in understanding dynamics and change (Sawyer, 2005). To some extent, systems thinking cannot get around using the reductionist tools and approaches it so much seeks to avoid. That is, systems thinking sets boundaries to delineate what is relevant and what is not—such boundaries are often operational rather than spatial (Luhmann, 1991). Systems thinking introduces a set of concepts that help to map, explore, interrogate and give meaning to a complex problem at hand. These concepts include, but are not limited to: *feedback*, to delineate influences from with the system and influences outside of it; *delays*, to understand how quickly a system can react to a disturbance through a balancing feedback loop or how it may delay or speed up an amplifying feedback loop; *emergence*, to describe the behaviour or properties of the system that cannot be reduced to its parts; *dynamic equilibrium*, to highlight that a system is subject to ongoing change and inflow and outflow are required to keep it in balance; and, *non-linearity*, to highlight that the extent to which the behaviour or properties of a system have changed do not necessarily reflect to extent to which a part or parts of a system have changed. Finally, systems thinking acknowledges that, because of people's self-consciousness, the workings of a system or interaction between parts of a system cannot be taken for granted as an outsider to that system or that interaction (Mingers, 2015). Still, at some point those applying systems thinking must make decisions about which worldviews and knowledge to include in their systems analysis and which to leave out.

Third, among the main strengths of applying systems thinking to regulatory governance is that it challenges the idea of an ordered public administration that can achieve desired outcomes through highly specialised units and branches (Geyer & Rihani, 2010). Systems thinking does away with seeking the cause of a problem or solution to it in a specific administrative unit or branch, or parts of these. Systems thinking asks for a broad and deep understanding of identified problems and suggested solutions so that the solution is not going to make the situation (say, a current regulatory problem) worse of in the long run. If applied well to regulatory governance, systems thinking may help to increase the flexibility, adaptability and resilience of regulatory agencies and the regulatory sector as a whole (Meadows, 2008). Ultimately, ongoing application of systems thinking to regulatory governance may add a tendency of learning and inquiring to the day-to-day practice of development, implementation, and enforcement of regulation (Checkland, 1999). That is: an ongoing questioning of whether the 'regulatory system' performs as we would like it to perform; an ongoing learning from day-to-day practice; and an ongoing inquiry into how we can improve performance even further.

Final words

Throughout this research paper, I have aimed to make clear that the term 'regulatory system' as well as the increasing calls for systems thinking in regulatory reform are less benign than they seem at first glance. Yes, there is a great intuitive appeal to applying systems thinking to regulatory problems and challenges. However, we do not have many examples of how systems thinking is applied in regulatory reform, let alone have access to a strong evidence base of its performance in improving regulatory governance.

Applying systems thinking requires a good dose of realism and reflexivity when mapping, exploring, and analysing regulation through a systems thinking lens. It is less easy to think in systems and talk of systems that it appears to be at first glance. It is critical to be exceptionally clear about what you mean when talking in or of systems—and the literature reviewed in this research paper reminds us to ask others what they mean when they use systems thinking jargon.

Appendix A – Suggestions for further reading

Serving the growth of interest in systems thinking in public policy, scholars from various fields have started to publish 'popular science' books and relatively 'easy to read' academic books. Many of these provide superb introductions to the various strains of systems thinking discussed in this research paper. The following foundational and applied books (in no specific order) may be of interest to those who seek a further introduction into systems thinking and its use for regulatory governance and scholarship.

Thinking in systems: A primer (Meadows, 2008)

Donella Meadows (1941-2001) was a pioneering environmental scientist, perhaps most known for her involvement in *The Limits to Growth*—the book that build on systems thinking and computer modelling and started the debate about the limits of the earth's capacity to support human (economic) expansion (Meadows, Meadows, Randers, & Behrens, 1972). In *Thinking in Systems: A Primer*, Meadows very clearly sets out the strain of systems thinking that has inspired much of her work. Meadows unpacks systems in stocks, flows and feedback, and challenges us to think about the leverage points of systems: "places in the system where a small change could lead to a large shift in behaviour" (ibid., 145).

The Fifth Discipline: The Art and Practice of the Learning Organization (Senge, 2006)

Peter Senge (Massachusetts Institute of Technology, MIT) has popularized systems thinking in the management sciences with his book, *The Fifth Discipline: The Art and Practice of the Learning Organization*. In the book, Senge discusses a range of management (and related) problems and discusses them through a systems thinking lens by considering feedback loops. The book is a valuable read because of its hands-on application of systems thinking in a range of easy to understand examples. Senge spends considerable time and effort to explain how delays in or acceleration of feedback loops can make for valuable mechanisms to address complex problems, making this book an essential read.

Systems Thinking, Systems Practice (Checkland, 1999)

Professor Peter Checkland (Lancaster University) is one of the central figures in systems thinking and systems science. The 1999 version of book *Systems Thinking, Systems Practice* combines his ground-breaking work on the Soft Systems Methodology (SSM) with a retrospection. Checkland considers systems thinking a heuristic that helps to reduce the complexity of human interactions and transactions—he questions if there is truly such a thing as 'systems' in the world. SSM was developed because 'hard' systems engineering failed to cope with the complexities of human affairs. SSM provides an approach to question and study human interactions and transactions (an 'inquiring system').

Introduction to Systems Theory (Luhmann, 2013)

Professor Niklas Luhmann (1927-1998, University of Bielefield) was a sociologist and philosopher of social science. In *Introduction to Systems Theory*, Luhmann explains the key ideas and concepts of his systems theory. It is certainly not the easiest read in this list of books, but the book is relevant for those interested in exploring the various strains of systems thinking discussed in this research paper. The core of Luhmann's theory is that systems help reduce complexity and select a limited amount of information with which to make sense of that complexity. Different systems exist side-by-side in society, all with their own logic, jargon and coding of events and experiences.

Observing Law Through Systems Theory (Nobles & Schiff, 2013)

Because Luhmann's work is not the easiest to read, we are fortunate that many scholars have explored his work and made it easier to understand his work 'as such', and, equally important, made it easier to understand how it can be applied to legal and regulatory problems. The book by Professors Richard Nobles and David Schiff (both Queen Mary University of London), *Observing Law Through Systems Theory*, is an excellent text to consult would you get lost in Luhmann's work—or to consult before you begin exploring Luhmann's work.

Applied Systems Theory (Dekkers, 2015)

Applied Systems Theory by Dr. Rob Dekkers (University of Glasgow) explicitly engages with control processes and control theory, and thus control systems. This makes the book an exceptionally valuable read for those involved in regulatory governance and regulatory practice. Dekkers distinguishes between four control mechanisms (directing, feedforward control, feedback control, and completing deficiencies) that resonate with various approaches regulation as an approach to steering the behaviour of individuals and collectives. Dekkers' take on systems thinking provides a meaningful bridge between the systems thinking strains developed by scholars such as Luhmann and Teubner on the one hand and Meadows and Senge on the other (see Chapter 2 of this research paper for a discussion of the different strains).

Soft System Thinking: Methodology and the Management of Change (Wilson & van Haperen, 2015)

In *Soft Systems Thinking: Methodology and the Management of Change*, Professor Brian Wilson (Lancaster University) and Kees van Haperen explain how they have applied the Soft Systems Methodology (SSM) in a variety of areas, ranging from healthcare to law enforcement. It is a valuable read for those interested in applying SSM in their own context.

Systems Thinking for Social Change (Stroh, 2015)

Systems Thinking for Social Change is another practical application of systems thinking. In this book, David Peter Stroh explores and explains how different strains of systems thinking can be applied in practice. The book provides examples of the application of thinking in line with Meadows' and Senge's take on the topic, as well as application of the Soft Systems Methodology (SSM). The book is, perhaps, the most pragmatic of the applied books discussed here as it takes considerable freedom in how it applies the various models and heuristics provided in the 'foundational' systems thinking literature.

Complexity and Public Policy: A New Approach to Twenty-first Century Politics, Policy and Society (Geyer & Rihani, 2010)

Professor Robert Geyer (Lancaster University) and Dr Samir Rihani (University of Liverpool) argue that systems thinking and complexity theory challenge the orderly paradigm of public administration. In *Complexity and Public Policy: A New Approach to Twenty-first Century Politics, Policy and Society*, they explore and apply the traditional paradigm of order to public administration as well as the post-modernist paradigm of complexity and interpretivism. What makes the book of interest is that it concludes by providing a middle ground between these (somewhat) extreme paradigms. Geyer and Rihani explain how systems thinking and complexity theory can help in developing pragmatic but at the same time adaptive frameworks to provide long term solutions to challenging public problems.

System Thinkers (Ramage & Shipp, 2009), and Systems Practice: How to Act (Ison, 2017)

For those with an appetite for more on systems thinking and systems theory, these two books provide excellent starting points. In *Systems Thinkers*, Dr. Magnus Ramage and Karen Shipp (both Open University) discuss the history of systems thinking by introducing 30 leading systems thinkers. They divide the history of systems thinking in five broad lineages: early cybernetics, general systems theory, system dynamics, soft and critical systems, later cybernetics, complexity theory, and learning systems.

In *Systems Practice: How to Act*, Professor Ray Ison (Open University) illustrates how systems thinking can be applied to practical problems. The book explores various systems thinking lineages (including practical holism, general systems theory, operations research, complexity sciences, first-order cybernetics, second-order cybernetics, and interdisciplinary systems sciences) and explains what it takes to apply systems thinking in practice.

Appendix B – Methodology

The meta-review presented in this article builds on a broad reading of the academic literature of systems thinking, systems science, and systems theory published in English since the late 1960s. Following conventional practice for the type of meta-review presented here (Campbell Collaboration, 2018; Gough, Oliver, & Thomas, 2012), documents were sourced from Scholar Google. Foundational texts on systems thinking and systems science were identified by their citation count. This resulted in a set of 21 monographs, one edited book, three book chapters, and four journal articles that do not overlap substantially with the books and chapters. This set was complemented with 14 publications (books, chapters and journal articles), cited in these 29 foundational texts, that apply or discuss systems thinking in the context of public policy in general and regulatory governance in particular ('snowball sampling').

All 43 publications (the 29 foundational publications and 14 additional ones) were read, and notes were kept in a working document. This document was coded and analysed (using Atlas.ti, version 8) to capture the 'repetitiveness' and 'rarity' of themes and findings reported across the various publications (cf., Bearfield & Eller, 2008; and Sutton, Papaioannou, & Booth, 2016). Table B.1 gives an overview of the codes used. Insights presented in chapters 2 and 5 build on this set of publications.

The evidence review presented in Chapter 4 builds on a review of peer-reviewed articles in the top 15 journals for regulatory scholarship.[5] For that review, articles were systematically sourced from the journals' online databases using key word searches. In a first step, these databases were explored to identify articles that likely engage with systems thinking and systems science and have a regulatory focus. The key word searches were: "complex system*" OR "adaptive system*" OR "system* theory" OR "soft system*" OR "dynamic system*" OR "system* think*" AND regulat*. The asterisk (*) operates as a wildcard—for example, the term 'regulat*' allows the search to find 'regulation', 'regulating', 'regulate', 'regulator', etc. After removing duplicates, this initial search resulted in a set of 637 peer-reviewed journal articles.

In a second step, all abstracts of these articles were read to identify those publications that explicitly engage with regulatory governance—including regulatory policy, regulatory design, regulatory delivery, regulatory practice, regulatory regimes, regulatory enforcement and compliance with regulation. This step resulted in 59 articles articles that have a central focus on a regulatory topic and use systems thinking terminology.

In a third step, all 59 articles were read to trace those that explicitly engage with systems thinking and systems science. This step resulted in a set of nine articles that explicitly apply ideas and concepts from the systems thinking literature to a regulatory topic. As a reliability test, a check of the original 637 articles was carried out by randomly selecting one in four of these and fully reading the articles selected (providing a confidence level of 95% with a margin of error of 7%). Of a total of 159 articles randomly read, only three were traced that engage with the systems thinking literature and have a

[5] The journals are: Regulation and Governance, the Journal of Public Administration, Research and Theory (JPART), Law and Policy, Public Administration, Governance, the Journal of Policy Analysis and Management, Public Administration Review, Public Management Review, the Policy Studies Journal, Policy Sciences, Politics and Society, Administrative Science Quarterly, Social and Legal Studies, the Journal of Law and Society, and the International Journal of Law in Context.

central focus on a regulatory topic—these three articles overlap with those identified in the stepwise selection process. This supports the limited number of articles traced in the third step.

In a fourth step, all articles were read, coded, and analysed following the procedure discussed above, using the codes presented in table B.1.

Table B.1 – Coding of the literature sourced

Codes used			
Adapting and learning	Emergence	Interaction and relationship	Regulation as communication
Advanced systems thinking	Environment	Introduction	Regulatory system explicit
Algorithm	Epistemic challenges	Limited use of systems theory in...	Relation
Assumed patterns across systems	Ethical challenges	Long term over short term	Satisficing/optimizing over perfect solution
Autopoiesis	Evidence	Luhmann	Self-organising and self-sustaining
Boundaries	Evolution	Meta regulation and meta rules	SSM applied to regulatory system
Closed systems	Examples	Method	Stocks
Collective over individual	Feedback/feedforward (and) loops	Modelling of regulatory system	Sum larger than the parts/wholeness/holistic
Complexity	Fitness (landscape)	Negative/balancing feedback	Systematic
Compliant behaviour (of regulatees)	Flows	Non-linear	Systematic/simple regulatory system
Conclusion	General use systems terminology	Open systems	Systemic
Coupling or structural coupling	Generalists over specialists	Oscillation and (time) delay	Systemic/complex regulatory system
Critique to (linear) causality	Hierarchy	Policy (sub)system	Systems definition
Cybernetics	Impossible to have all info	Positive/reinforcing feedback	Understanding regulatory failure
Develop better (sub)regimes	Impossible to manage/steer system behaviour	Pre systems thinking	Value of systems thinking for regulatory governance
Dynamic equilibrium	Impossible to predict system behaviour	Reductionist	Whole of government thinking
Early systems thinking	Information delay	Reflexive and reflexivity	

Of course, the initial focus of the review on publications in the top 15 journals for regulatory scholarship will have somewhat skewed the set of source publications underlying this review. The findings of the review are representative of how scholars of regulatory governance have engaged with systems thinking and systems science. The review is not comprehensive as it has not systematically explored how scholars of systems thinking and systems science have engaged with regulatory governance. That would ask for a review of publications from the systems science and cybernetic literature.

An unformatted Excel file of the 637 identified peer-reviewed journal articles and a Word file of the notes taken from the publications is available upon request. Please reach out to: Professor Jeroen van der Heijden, jeroen.vanderheijden@vuw.ac.nz.

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