View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Complexity, Governance & Networks (E-Journal - University of...

Complexity, Governance & Networks (2014) 17–28
DOI: 10.7564/14-CGN2

The Emergence of Complexity in the Art and Science of Governance[1]

Geert Teisman*, Lasse Gerrits

Erasmus University Rotterdam
E-mail: teisman@fsw.eur.nl; gerrits@fsw.eur.nl

We argue that the complexity of an interconnected society and its governance require a complexity-informed approach to our domain. Concepts and theories from the complexity sciences can help with this. There is a notable increase of the use of such concepts and theories but the theory transfer isn't as straightforward as it may seem. "Emergence" is helpful in understanding the particular differences between the various realms of science. Within the social sciences in general and public administration in particular, emergence highlights the non-decomposable, contingent, non-compressible and time-asymmetric nature of reality. Subsequently, we propose three methods that take these aspects into account when putting concepts from the complexity sciences to the test: qualitative comparative analysis, dynamic network analysis, and group model building.

Keywords: Complexity, governance, emergence, research methods, public administration, theory transfer.

1. Complexity in network societies and governance networks

In this paper, we elaborate how the notions of complexity are penetrating the practice and the science of public administration. We see a growing attention for complexity science and postulate that this attention is powered by the potential of the complexity sciences on the one hand, and by an increase of complexity in society and government on the other hand. This urges scholars in public administration to develop theories and concepts that fit with this complexity and that help to understand government actions in complex systems.

As with many other new paradigm shifts in public administration in the past – the emergence of network theory, just to mention a relative recent one – the application and adoption of 'the new kid in town' is not without questions and doubt. Pollitt, by invitation, formulated his critique in Teisman, Van Buuren, & Gerrits (2009), who presented

[1] We are grateful to Göktuğ Morçöl for his thorough review of an earlier version of this article.

* Corresponding author.

CC BY SA

their insights about government systems from a complexity theoretical paradigm. These critiques are important because they address the things that a framework under development still lacks. It inspires the authors of this contribution to continue with their attempts to make complexity theory useful for public administration and to present evidence for the added value of this paradigm.

We believe that the emergence of network societies, in which global networks of important local hubs are interrelated and in interaction, contribute to societal development and, consequently, to the emergence of governance theories that deliver the pertinent insight that effective steering comes from joint actions – whether in competition, cooperation of both – than from one single organization that is presumably in charge. This is an important driver in the field of public administration to apply complexity concepts and theories.

The complexity sciences have the potential to obtain a more sophisticated and more dynamic understanding of the pattern of interdependencies underlying the kind of situations practitioners find themselves confronted with. However, the aim of this contribution is not to outline main features of complexity sciences and concepts from complexity theory like co-evolution and initial conditions. For these discussions on complexity sciences in relation to public administration we can refer to previous studies (Gerrits, 2012; Morçöl, 2012, 2014 [in this issue]; Teisman & Klijn, 2008; Teisman, et al., 2009). In this contribution we will turn towards the art of research in the domain of public administration from a complexity theoretical approach. We will elaborate the ability of public administration scholars to do complexity-informed research. Complexity-informed research is able to deal with blurred issues that are not easily definable and demarcated, with large amounts of data that are not coherent and countable in a direct sense and with relations that reach beyond simple takes on causality. The challenge is to gain scientific and transparent insights from a variety of messy data, delivered by a variety of contributors and sources. ***Theory transfer*** and ***complex causality*** are the two sensitizing concepts we use in our search into complexity-informed research techniques, methods and methodology. Theory transfer is the art of constructing a cross-over between two different disciplines, sometimes far away from each other. In that cross-over, the theory is applied in a new context. By doing so the theory also can be reshaped and show new advantages. This is comparable to commercial cross-overs in which materials used in a technical context get a new application and life once applied in a social context. Here we elaborate the theory transfer of complexity-informed research and research methods.

2. Simple behavior emerges into complex systems

To many academics in public administration, Waldrop's (1992) book provides a first introduction to complexity sciences, in particular to the works of scientists of the famous Santa Fe Institute, including John Holland, Brian Arthur, and Murray Gell-Mann. Waldrop's accessible narrative presents the contributions of these scientists in a heroic fashion against a backdrop of scientific breakthroughs. It is commonly agreed that the scientists at Santa Fe Institute have played a major role in the emergence of what has become known as complexity theory, or more precisely, the complexity sciences as a collection of theories that focus on a number of related phenomena in physical and social systems, such as emergence, non-linearity, self-organization and coevolution.

The theories developed at the Santa Fe Institute are characterized by an algorithmic approach. The core idea is that complex patterns emerge from simple (behavioral) rules. As an example consider the "boids simulation," which was developed by Reynolds (1987). Boids simulate flock-like behavior of e.g. herds of cattle and schools of fish. Many scientists are intrigued by the dynamic shapes of these phenomena and by the fact that these "boids" seem to have a life on their own that is rather complex and dynamic.

An important aspect of these simulations is that simple behavioral rules can generate complex, seemingly "living", systems, and that these complex systems are able to deal with challenges. When released in a simulated environment with a number of obstacles, the boids are able to maintain a coherent mutual structure whilst avoiding those obstacles when moving about. The simulation indicates that one does not need to design and superimpose complex rules for individual member of the boids to maintain a coherent – though not fixed - structure under changing circumstances. The resulting patterns resemble the "flocking behavior" of birds, cattle and fish and demonstrate how complex wholes can emerge from simple individual action.

The emergence of complex patterns and behaviors Reynolds demonstrated were observed by e.g. Axelrod (1986, 1997) and Holland (1995, 2006) as well, who use these ideas to understand the complexity of human cooperation. Holland investigated and conceptualized the mechanisms of emergence and pointed them out as the origins of complexity.

The concept of emergence opens new avenues of inquiry. In particular, it promises social scientists that there is order behind the ostensible chaos in network societies and it promises public administration scientists that there is order behind the ostensible chaos of numerous government actions and changes of course. The message here is that the individual behavior has a non-linear relationship to the whole in which the individual operates. In other words: what happens on the micro-level is related to the macro-level, but not to the extent that individual actions are fully mirrored in the whole. As society becomes more fragmented, specialized and compartimentalized, it means that the ostensible disconnect of the relationship between the two levels becomes more prominent. It may further obscure that relationship but it is still there and deserves a concerted research effort.

Emergence, then, can help explaining the complex causal patterns social scientists are faced with. It draws attention to the fact that social reality is a living, organic and dynamic systemic whole comprised of individual behaviors. This whole cannot substantially be understood if scientists only study its discrete parts without understanding the systemic whole in which they are embedded. When taken apart in discrete elements, the integrity as a system of ongoing interaction will be violated (Gerrits & Verweij, 2013), Attempts to understand this multilevel phenomena are being made, but not very successful because the connections are made conceptually but are notoriously hard to trace empirically. Simulations, for instance, demonstrate diachronic emergence where there is a clear starting point and clear final result. In other words: emergence here is seen as something that has an unambiguous t = 0.

In social reality, however, there is obviously no such thing as a clear starting point where everything is fixed until some activates 'time'. And as any scholar in public administration knows: an outcome – whether from policy or any other type of decision – is a far from clear. In other words: our object of research is characterized by synchronic emergence where the temporal division between parts and whole is brought back into one single but continuous instant (Elder-Vass, 2005). Simplistic methods will simply not deliver here.

The similarities and differences between algorithmic emergence and emergence in social reality are a marker of the similarities and differences between the natural sciences, from which complexity theories originate, and the social sciences. Adaptations to the social sciences, in particular to our domain, initially provided a vocabulary and set of concepts that opened up new avenues of thought. For example, consider how Teisman (1992) analyzed the decision-making processes of infrastructure projects and found that such decision-making, whilst moving forward in time, does not adhere to the assumptions of synoptic, diachronic processes and that none of the actors involved were ever able to play a constantly decisive role. Yet, decision structures emerged over time and projects were built. A thoroughly empirical-based understanding of decision-making has gained ground and the complexity sciences provided new ways in which such dynamics could be understood. In other words, the complexity sciences provided a boost to theory development in our domain.

Early adopters of complexity theory in public administration are Haynes (2001, 2003), Kickert (1991), Kiel (1989), and Morçöl and Dennard (1997). Broadly speaking, we can distinguish between two types of contributions. Kiel and Kickert attempted to replicate the scientific approach in the source domain of complexity sciences in the target domain of public administration. They tried to find the same mechanisms of emergence and self-organization in biological systems in the world of public administration, public policy, or public management. The other group of authors used the general ideas and concepts from the source domain as points of departure and translated them for the target domain. They did not merely copy the concepts, but transformed them to make them applicable in the target domain. They applied the original concepts as metaphors to make sense of the complexity of the target domain. For example, they may draw parallels between Lorenz' butterfly effect and the actions of a public manager or they may modify Kauffman's fitness landscape to suit the daily reality of said manager (see e.g. Geyer & Rihani, 2010; Stacey & Griffin, 2006).

These differences are testimony of the dynamics of theory transfer between the physical sciences from which the complexity sciences originate, and the social sciences. It raises questions such as whether it is possible to replicate methods from the natural sciences in the social sciences and whether a causal patterns established in e.g. physics or biology still holds true in social reality. Upon closer examination, it seems that a considerable number of applications in our domain use concepts from the complexity sciences as a metaphor. Metaphors can provide genuine insight in the target domain but may lead to disappointment if not applied properly (see e.g. Chettiparamb, 2006; Lakoff & Johnson, 2003; Rosenhead, 1998, for extended arguments). Despite initial interest, there have therefore also been scientists who have questioned the use of the endeavor, especially given the difficulties of theory transfer. For example, Pollitt (2009) states that the complexity sciences promise more than that they deliver, in particular that authors wrap fancy jargon around trite issues such as policy failures and span of control. The difficulties in applying the complexity sciences to the social realm, the liberal use of metaphors and analogies and the well-worded criticism could make the endeavor appear a passing fad.

More recent works (e.g. Gerrits, 2012; Morçöl, 2012; Room, 2011a, 2011b; Teisman, et al., 2009) take into account the issues of theory transfer, operationalization of main concepts, and the use of complexity-informed methods and demonstrate how complexity theory can lead to a better understanding of the messy day-to-day reality of policymakers and administrators. Over time, it has become clearer how the complexity sciences can inform public administration. For example, researchers demonstrated how complex adaptive systems can lease a second life to Easton's cybernetics (Flood, 1999), how original idea of punctuated equilibrium (Eldredge & Gould, 1972) can be operationalized and analyzed to understand the dynamics of the policy agenda (Baumgartner & Jones, 1993), and how evolutionary theories can inform the analysis of institutions (Nelson & Winter, 1982). It is justified to say that conceptual leaps have been made and that we are now better at making sense of public administration and public management. It means that we have become better at theory transfer. But concepts need thorough testing and for that we need complexity-informed methodological tools. As argued above, not every method is well-suited for dealing with the synchronic emergence that drives social reality. In the following section, we want to highlight the importance of the complexity sciences in understanding the nature of causality in the social sciences.

3. Uncovering Complexity in Social Reality

One of the most important recent developments in the realm of social complexity is the understanding that theoretical concepts, such as emergence and self-organization, are basically expressions of the nature of causality. We follow Byrne (1998, 2005, 2011) and take his concept of "situated complexity" as our point of departure in understanding social reality. Byrne suggests that social reality is a compound of generic or recurring patterns in conjunction with idiosyncratic events, i.e. events that are local in place and temporal in time. As such, social reality is not exclusively governed by universal laws, but each event is not unique either. Causal patterns are comparable across cases, yet at the same time, they differ with unique elements generated by unique contexts or circumstances (Buijs, Eshuis, &, Byrne, 2009).

Accepting this ontological point of departure means that we embrace the classic scientific idea of science that lessons can learned from cases in the (recent) past into cases of the (near) future (the art of generalization). At the same time, we accept the idea that certain events from the past recur only occasionally. They are adjusted by, and combined with, unique contextual variables. Science can still be based on the evidence collected in the past, but one cannot learn from this evidence simply by copying it; the knowledge of the past must be adjusted to fit new circumstances. This is the creative and transformative element of using ‘best practices’.

More specific, a public administration theory rooted in synchronic emergence should be based on the postulate that social reality is non-decomposable, contingent, non-compressible, and time-asymmetric (Gerrits & Verweij, 2013). The non-decomposable nature of reality has in fact been discussed above and implies that breaking reality into discrete elements for the sake of analysis violates its interrelatedness. Important external forces would be at the risk of being overlooked. Reality functions as a whole and this means that science is challenged to treat it as such. Contingency refers to the fact that context is explanatory for which mechanisms are actually triggered and which are not (e.g. Mjøset, 2009). It highlights that complex systems are neither governed by general rules nor by pure idiosyncracies, as pointed out by Byrne above. In other words: context determines equifinality and multifinality. Taking these two points together, it is clear that reality is non-decompressible because that would make it loose some of its decisive aspects.

Time asymmetry, the fourth point, holds that complex systems are developmentally open because of the occurrence of chance events leading to non-linear change (Prigogine, 1997). In other words, trajectories of the past will not be mirrored in the present and the future. This calls for a longitudinal and detailed approach to research, as the emergence of structures and processes cannot be deduced in a linear fashion (Gerrits, 2011, 2012). Inevitably, any scientific method or model is reductionist (Cilliers, 2002, 2005a, 2005b). As researchers struggle to understand the system as a whole, respecting its integrity, they also try to keep research manageable. Although a truly holistic research project is not possible, there still is an important difference between accepting a method’s limitations and accepting Ockham’s razor (Gerrits, 2012).

4. Examples of Complexity-Informed Methods

The four ontological points above set the coordinates to guide the selection of suitable, complexity-informed methodologies for doing empirical research in our domain. Here, we want to focus on three interesting methods: qualitative comparative analysis (QCA), dynamic network analysis (DNA), and group model building (GMB).

Qualitative comparative analysis (Ragin, 1987, 2000, 2008) was proposed by Byrne (2005, 2011) and Byrne and Ragin (2009) as a particularly effective method in uncovering situated complexity because it preserves the contextual details of cases through systematic and transparent comparative procedures. As such, it negates the trade-off between rich single in-depth case studies and the less-detailed case comparisons that can reveal recurring patterns across those cases. In other words, it helps gaining a better understanding of the issue of contingency mentioned above.

For example, Verweij and Gerrits (2014) compared 18 cases of infrastructure project implementation in the Netherlands to understand which management strategies led to satisfaction about the projects among all actors involved in them. Using QCA, we found that there were different pathways to similar outcomes. We found that a general pattern that showed that under diverse circumstances, an externally-oriented project management approach in which public and private actors cooperate, leads to high satisfaction with the projects' outcome. But under certain specific conditions and depending on the nature of cooperation between principal and contractor, an internally-oriented management approach was also associated with high satisfaction. In addition we found that such an internally-oriented approach could also lead to dissatisfaction under specific different circumstances (Verweij & Gerrits, 2014). In short, we found that there are several contingent pathways towards the outcomes "high satisfaction" and "low satisfaction" with the projects' results. As such, the authors have demonstrated equifinality in the management of infrastructure projects by focusing on how outcomes – note the plural here – are produced in conjunction with the specific conditions of a certain phenomenon.

Dynamic Network Analysis (DNA; Carley, Diesner, Reminga, & Tsvetovat, 2007) is an extension of social network analysis. It builds on the assumption that actors operate in networks, and adds that such networks are dynamic in composition and ties and that these dynamics can be captured by juxtaposing actor-networks with others, such as knowledge networks and resource networks. This juxtaposition of different types of networks in DNA is based on the "affiliation networks" concepts and methods developed by social network analysis researchers. DNA can also capture the state of the overall network at several points in time (Carley et al., 2007). Although not mentioned explicitly in the literature on DNA, it embodies the nature of complex adaptive system by introducing time and feedback loops in the analysis in terms of actions and responses. As such, it enables to researchers to investigate structure and process simultaneously in a rigorous way.

Schipper and Gerrits (2014) deployed DNA in an investigation of the daily operations of the Dutch railway system (Schipper & Gerrits, 2012, 2014). While the network of train operators, train dispatcher, signalers, etc. is quite capable in dealing with most of the common disruptions in the railway system, it fully fails when trying to cope with major events such as heavy snowfall or technical failures in rolling stock. In such cases, decisions made by those actors cascade through the network, where each decision reinforces the effect of the previous decision to the extent that the railway system as a whole collapses (Leveson, Dulac, Marais, & Caroll, 2009). Using DNA, the researchers were able to reconstruct the information flows in the system, i.e. which decisions were taken and how others responded to that, the tasks that were executed and how these changed over time, and the cognitive workload associated with this. As such, the researchers obtained a systemic overview of the railway system during a disruption and were able to trace the systemic properties back to the individual actions, i.e. emergence.

Among the methods discussed here, Group Model Building (GMB) has been around for the longest time. GMB originated from the studies in system dynamics modeling (Majone & Quade, 1980; Quade, 1975). While early iterations of systems theories appeared too mechanistic, they have been improved continuously, particularly business administration and organizational sciences. Checkland (1981) and Flood (1999) developed increasingly sophisticated conceptualizations and methods for understanding system dynamics that take into account semiotics, learning, and sense-making. GMB represents one of such iterations (Vennix, 1996). It combines the modeling of a particular policy problem with participatory group learning and a sense-making process among stakeholders. As such, it provides researchers with a tool to discover the causal linkages and feedback loops of a given issue, whilst at the same time giving stakeholders the opportunity to learn about the real causes and consequences of that particular issue.

In an application of GMB in two projects with the Rotterdam municipal authorities (Vaandrager, Gerrits, & Bressers, 2014), it was found that the respondents sought the causes of the policy deadlocks outside their realm of control. They pointed towards politicians or to other organizations and felt themselves as victims of the circumstances. By jointly building a system's model of that particular policy deadlock, they started to see that they were dealing with a systemic issue that was badly understood because their own views and needs where firmly bounded by the organizational interests, which made them feel helpless while they were in fact able to change the way things were being done. They gained this insight through joint model-building and visual representations of the models made by the researchers. These visualizations helped to capture the complex systemic dynamics, consequently leading to a change in the mental modes of the participants and offering sweet spots in the system where policy intervention was possible.

The methods acknowledging complexity- mentioned here are a selection from a broader suite of methodologies that range from narrative analysis (see e.g. Uprichard & Byrne, 2006; Wagenaar, 2007 for examples) to computation modeling (see e.g. Catlaw & Kim, 2012; Koliba & Zia, 2012 for examples, and Morçöl, 2012, for more extended overview). Increasingly, accessible software programs allow researchers to unlock the potential of such methods and to deal with the high number of observations necessary to gain a deeper understanding of the complexity of public policy issues. In addition, such programs can visualize this complexity, which is very helpful in communications. For example, Vensim provides a comprehensive yet accessible toolbox to create systemic visualization of the system of stocks and flows. ORA does the same for the combined networks in DNA, and Tosmana for QCA visualizes the solution formula with maximum five independent conditions. We want to stress the importance of visualization because it really helps to convey the intricate details found in the analysis. It is our experience that many people, especially practitioners, understand complexity in an intuitive way but a concerted research effort is necessary to uncover the real complex causality underlying social phenomenon and to communicate about them with scientists and practitioners.

5. Conclusions

The networked society is characterized by self-generating mutual interdependencies between actors. Networks challenges the 21st century's organizing principle of hierarchical bureaucracies. This is reflected in public administration in the shift from government to governance. Similarly, the increasing complexity of society needs to be reflected in contemporary research in our domain. The complexity sciences offer a promising conceptual and methodological suite to approach complexity.

In this contribution, we looked at the aspects of theory transfer and complex causality. We found that theories in the source domain can be very helpful in the target domain, i.e. public administration, but that such a transfer needs to be tailored to the specifics of social reality. The concept of emergence makes this point most prominently. Subsequently, we postulated four aspects of emergence to which methodologies should adhere, and we discussed three suitable research methods. QCA focuses on the nested nature of social reality, DNA focuses on the dynamics of connections in networks, and GMB combines a participatory approach with identification of the leverage points and feedback loops that build the system. Naturally, the proof of the pudding is in the eating and it is therefore necessary to put these methods and the concepts to the (empirical) test. This journal will provide an excellent outlet for that.

References

Axelrod, R. (1986). An evolutionary approach to norms. *The American Political Science Review, 80*(4), 1095–1111.

Axelrod, R. (1997). *The complexity of cooperation: Agent-based models of competition and collaboration*. Princeton, NJ: Princeton University Press.

Baumgartner, F. R., & Jones, B. D. (1993). *Agendas and instability in American politics*. Chicago, IL: The University of Chicago Press.

Buijs, M. J., Eshuis, J., & Byrne, D. S. (2009). Approaches to researching complexity in public management. In G. R. Teisman, M. W. Van Buuren, & L. M. Gerrits (Eds.), *Managing complex governance systems: Dynamics, self-organization and coevolution in public investments* (pp. 37–55). New York, NY: Routledge.

Byrne, D. S., & Ragin, C. C. (2009). *The Sage handbook of case-based methods*. London, England: Sage.

Byrne, D. S. (1998). *Complexity theory and the social sciences: An introduction*. London, England: Routledge.

Byrne, D. S. (2005). Complexity, configurations and cases. *Theory, Culture & Society, 22*(5), 95–111.

Byrne, D. S. (2011). *Applying social science: The role of social research in politics, policy and practice*. Bristol, England: The Policy Press.

Carley, K. M., Diesner, J., Reminga, J., & Tsvetovat, M. (2007). Toward an interoperable dynamic network analysis toolkit. *Decision Support Systems, 43*(4), 1324–1347.

Catlaw, T.J., & Kim, Y. (2012). Philosophies of multiplicity and simulation: Possibilities for public affairs inquiry. In L. M. Gerrits, & P. Marks (Eds.), *COMPACT I: Public administration in complexity* (pp. 26-40). Litchfield Park, AZ: Emergent.

Checkland, P. (1981). *Systems thinking, systems practice*. Chichester, England: John Wiley & Sons.

Chettiparamb, A. (2006). Metaphors in complexity theory and planning. *Planning Theory, 5*(1), 71–91.

Cilliers, P. (2002). Why we cannot know complex things completely. *Emergence, 4*(1/2), 77–84.

Cilliers, P. (2005a). Complexity, deconstruction and relativism. *Theory, Culture and Society, 22*(5), 255–267.

Cilliers, P. (2005b). Knowledge, limits and boundaries. *Futures, 37*(7), 605–613.

Elder-Vass, D. (2005). Emergence and the realist account of cause. *Journal of Critical Realism, 4*(2), 315–338.

Eldredge, N., & Gould, S. J. (1972). Punctuated equilibria: An alternative to phyletic gradualism. In T. J. M. Schopf (Ed.), *Models in paleobiology* (pp. 82–115). San Fransisco, CA: Cooper & Co.

Flood, R. L. (1999). *Rethinking the fifth discipline: Learning within the unknowable*. London, England: Routledge.

Gerrits, L. M. (2011). A coevolutionary revision of decision making processes: An analysis of port extensions in Germany, Belgium and the Netherlands. *Public Administration Quarterly, 35*(3), 309–339.

Gerrits, L. M., & Verweij, S. (2013). Critical realism as a meta-framework for understanding the relationships between complexity and qualitative comparative analysis. *Journal of Critical Realism, 12*(2), 166–182.

Gerrits, L. M. (2012). *Punching clouds: An introduction to the complexity of public decision-making*. Litchfield Park, AZ: Emergent.

Geyer, R., & Rihani, S. (2010). *Complexity and public policy: A new approach 21st century politics, policy and society*. New York, NY: Routledge.

Haynes, P. (2001). Complexity, quantification and the management of policy. *Social Issues, 1*(2), 1–12.

Haynes, P. (2003). *Managing complexity in the public services*. Maidenhead, England: Open University Press.

Holland, J. H. (1995). *Hidden order: How adaptation builds complexity*. Jackson, MS: Perseus Books.

Holland, J. H. (2006). Studying complex adaptive systems. *Journal of Systems Science and Complexity, 19*(1), 1–8.

Kickert, W. J. M. (1991). *Complexiteit, zelfsturing en dynamiek*. Rotterdam, NL: Erasmus Universiteit Rotterdam.

Kiel, L. D. (1989). Nonequilibrium theory and its implications for public administration. *Public Administration Review, 49*(6), 544–551.

Koliba, C., & Zia, A. (2012). Theory testing using complex systems modeling in public administration and policy studies: Challenges and opportunities for a meta-theoretical research program. In L. M. Gerrits, P. M. Marks & F. A. A. Boons (Eds.), *Public administration in complexity*. Litchfield Park, AZ: Emergent.

Lakoff, G., & Johnson, M. (2003). *Metaphors we live by*. Chicago, IL: Chicago University Press.

Leveson, N., Dulac, N., Marais, K., & Carroll, J. (2009). Moving beyond normal accidents and high reliability organizations: A systems approach to safety in complex systems. *Organization Studies, 30*(2–3), 227–249.

Majone, G., & Quade, E. S. (Eds.). (1980). *Pitfalls of analysis*. Chichester, England: Wiley.

Mjøset, L. (2009). The contextualist approach to social science methodology. In D. S. Byrne & C. C. Ragin (Eds.), *The Sage handbook of case-based methods* (pp. 39–68). London, England: Sage.

Morçöl, G. (2012). *A complexity theory for public policy*. New York, NY: Routledge.

Morçöl, G (2014). Complex governance networks: An assessment of the advances and prospects. *Complexity, Governance and Networks*, *1*, 5–16.

Morçöl, G. & Dennard, L. F. (1997). Learning from the natural sciences: An introduction. *Administrative Theory & Praxis, 19*(3), 299–304.

Nelson, R. R., & Winter, S. G. (1982). *An evolutionary theory of economic change*. Cambridge, England: Harvard University Press.

Pollitt, C. (2009). Complexity theory and evolutionary public administration: A skeptical afterword. In G. R. Teisman, M. W. Van Buuren, & L. M. Gerrits (Eds.), *Managing complex governance systems: Dynamics, self-organization and coevolution in public investments* (pp. 37–55). New York, NY: Routledge.

Prigogine, I. (1997). *The end of certainty: Time, chaos, and the new laws of nature*. New York, NY: Free Press.

Quade, E. S. (1975). *Analysis for public decisions*. New York, NY: American Elsevier.

Ragin, C. C. (1987). *The comparative method: Moving beyond qualitative and quantitative strategies*. Los Angeles, CA: University of California Press.

Ragin, C. C. (2000). *Fuzzy-set social science*. Chicago, IL: University of Chicago Press.

Ragin, C. C. (2008). *Redesigning social inquiry: Fuzzy sets and beyond*. Chicago, IL: University of Chicago Press.

Reynolds, C. W. (1987). Flocks, herds, and schools: A distributed behavioral model. *Computer Graphics*, *21*(4), 25–34.

Room, G. (2011a). *Complexity, institutions and public policy: Agile decision-making in a turbulent world*. Cheltenham, England: Edgar Elgar.

Room, G. (2011b). Social mobility and complexity theory: Towards a critique of the sociological mainstream. *Policy Studies*, *32*(2), 109–126.

Rosenhead, J. (1998). *Complexity theory and management practice.* (scientific paper no. LSEOR 98.25). London, England: Department of Operational Research, London School of Economics.

Schipper, D. & Gerrits, L. (2012). On the Origin of the MRA. A coevolutionary analysis of the life-and-death cycles of urban governance in the Amsterdam metropolitan region. *ASPA Annual Work Conference: Las Vegas* (March 2 - March 6, 2012).

Schipper, D., & Gerrits, L. M. (2014). *An exploration of the possibilities of using DNA in analyzing complex system disruptions*. Paper presented at EGOS 2014, Rotterdam.

Stacey, R. D., & Griffin, D. (Eds.). (2006). *Complexity and the experience of managing in public sector organizations*. New York, NY: Routledge.

Teisman, G. R. (1992). *Complexe besluitvorming, een pluricentrisch perspectief op ruimtelijke investering ((Netwerken, complexiteit en dynamiek))*. Den Haag, NL: Elsevier.

Teisman, G. R., & Klijn, E. H. (2008). Complexity theory and public administration; an introduction. *Public Management Review, 10*(3), 287–297.

Teisman, G. R., Van Buuren, M. W., & Gerrits, L. M. (Eds.). (2009). *Managing complex governance systems: Dynamics, self-organization and coevolution in public investments*. New York, NY: Routledge.

Uprichard, E., & Byrne, D. (2006). Representing complex places: A narrative approach. *Environment and Planning A, 38*(4), 665.

Vaandrager, D., Gerrits, L. M., & Bressers, N. (2014). Reconstructing the blue connection: A systemic inquiry into the improbable project of building a new river through a (sub)urban area. *Systems Research and Behavioral Science*. [Accepted]

Vennix J. A. M. (1996). *Group model building, facilitating team learning using system dynamics*. Chichester, England: John Wiley & Sons.

Verweij, S., & Gerrits, L. M. (2014). How satisfaction is achieved in the implementation phase of large transportation infrastructure projects: A qualitative comparative analysis into the A2 tunnel project. *Public Works Management and Policy*, doi:10.1177/1087724X13518743.

Wagenaar, H. (2007). Governance, complexity and democratic participation: How citizens and public officials harness the complexities of neighborhood decline. *The American Review of Public Administration, 37*(1), 17–50.

Waldrop, M. M. (1992). *Complexity: The emerging science at the edge of order and chaos*. New York, NY: Touchstone.