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Beyond Experiments

Innovation in Climate Governance

BRUNO TURNHEIM, PAULA KIVIMAA AND FRANS BERKHOUT

1.1 Experiments in Climate Governance

In this edited volume, we are interested in understanding how experiments in climate governance can lead to broader changes in rules, practices, norms and other wider outcomes of efforts to respond to the challenges of climate change. We start with three observations about experiments in climate governance as entry points for some more general reflections about how change in governance comes about *from below*, rather than as a result of coordinated policymaking from above.

First, climate governance experimentation has become a legitimate object of research and is a practice attracting interest among policymakers and citizens. There is, therefore, an opportunity to analyse the motivations, direct outputs and broader outcomes of these initiatives. We want to ask what do these experiments add up to, and whether they influence deeper change in the legitimacy and effectiveness of climate governance. This is the broader policy context on this volume.

Second, climate governance experimentation is linked to the search for new ways of dealing with the causes and consequences of climate change, often at the margins of formal and established governance regimes, and in ways that are often temporary and local. We seek to understand what happens beyond this initial experimental setting. How do the ideas, networks and capabilities that emerge and are partially stabilised in experimental settings come to have a broader impact across policy and political systems? This provides a general problem and intellectual challenge for this volume.

Third, climate governance experimentation is a multifaceted object of study that compels a view from different perspectives. With this volume we seek to draw on the richness of a variety of conceptual and methodological traditions to further our understanding of governance experimentation in the context of climate change. In particular, we have sought to bring scholars of governance and of innovation together to reflect on climate policy experiments and their broader impacts beyond

the original experimental setting. We do so by encouraging and setting the terms of a constructive dialogue between these quite distinct approaches. This provides an interdisciplinary orientation to this volume.

1.1.1 The Growing Attention to Climate Governance Experiments

In common with other areas of policy studies (Greenberg, Links and Mandell, 2003; Tassey, 2014), there has been a growing academic and policy interest in experimentation in governing the causes and consequences of climate change over recent years. This is evident across different scales, from local communities and cities (cf. Blok and Tschötschel, 2016) to policy communities (McFadgen and Huitema, 2017) and international organisations.

There appear to be a number of reasons for this revived interest (Sabel and Zeitlin, 2012). First, experimentation is seen as a mode of response well suited to the challenges of mitigating climate change and adapting to climate risks. It is argued that experiments are better attuned to the complex, situated and uncertain character of the climate change problem than more traditional modes of governing through national and international policy (e.g. Broto and Bulkeley, 2013; Bulkeley, Broto and Edwards, 2014; McFadgen and Huitema, 2016). In particular, governance experiments appear to be fitting when responding to uncertainties and incentive problems confronted by local climate action. The literatures on risk governance (Renn, Klinke and van Asselt, 2011), polycentric governance (Ostrom, 2010; Jordan et al., 2015) and urban experimentation (Bulkeley et al., 2014) recognise the limited capacity of national and international policy regimes to address global climate change effectively. This failure accounts for the ‘groundswell of actions on climate change mitigation and adaptation from cities, regions, businesses, and civil society organizations’ (Chan et al., 2015:476). According to some commentators, the failure of the 15th session of the Conference of the Parties (COP 15) in Copenhagen (2009) strengthened a mandate for decentralised, bottom-up climate interventions – a shift in climate governance internationally that was confirmed at COP21 in Paris (2016) that placed greater emphasis on voluntarism at the national level (‘pledge and review’) and a greater role for non-state action and subnational actors (van Asselt, Huitema and Jordan, Chapter 2). The ‘experimental turn’ in climate governance can be viewed as a rejection of the perceived failures of coordinated and global approaches to climate action, whether that coordination was achieved through governments or markets. Experimentalism has been presented as an entrepreneurial approach, stressing agency over coordination, with coordination itself viewed as emergent and *organic*, drawing on the norms, incentives and relationships of actors at a more granular level.

Second, experimentalism is being embraced as a principle for action in an area that is fraught with uncertainty, complexity, diffuse authority and agency, justified by the need to design provisional goals and to fine-tune through comparative learning (Sabel and Zeitlin, 2010; De Búrca, Keohane and Sabel, 2014). In this view, experimentation is more than a means to an end. The function of experimentation is not merely to encourage learning or to build up actor coalitions that can propel change. Instead, experimentalism is seen as a new approach to climate governance itself; that is, it is a transformation in governance in its own right. This debate on experimentalist governance extends well beyond the issue of climate change (Sabel and Zeitlin, 2012), but it points to a deeper set of problems in complex, polycentric and multilevel governance systems.

In either case, experimentation represents a challenge to climate governance as conventionally conceived and practiced. Often, experiments are inscribed in processual narratives linking demonstrations, pilots and field trials with the promise of a deeper link to motivations and incentives of actors, and generalisable and replicable approaches. However, the true value of governance experiments in serving as microcosms that can be disseminated and reproduced is in question. For example, it is not clear how experimentation can generate outcomes beyond learning by those directly engaged in them, and the body of evidence documenting successful replication remains thin (Kivimaa et al., 2017).

Current enthusiasm for experimentation in climate governance explains the proliferation of initiatives and schemes. It also creates increased scope for reflection about the goals and consequences of experimentation: what experiments may lead to, beyond their particular and bounded contexts, and whether they can influence changes in norms, incentives, rules, behaviours and relationships more generally. This volume seeks to explore the question of what lies after and *beyond* experiments. In doing so, we aim to contribute to a critical analysis of climate governance experimentation. If experiments are largely uncoordinated and entrepreneurial initiatives by new coalitions of actors, what direct outputs do the experiments produce and how do they come to have broader influence? What notions of diffusion, reproduction and embedding can best describe the process by which the multiple possible outputs of experiments come to generate broader outcomes? These are deep conceptual challenges which each of the contributions in this collection grapple with and which we return to in Chapter 12.

1.1.2 Framing the Problem: Embedding Climate Governance Experiments

A good starting point for a volume about climate governance experimentation is to understand how experimentation became a promising approach for addressing global climate change. Climate change has been labelled a ‘wicked problem *par*

excellence' (Dryzek, 1987; Jordan et al., 2010; Levin et al., 2012; Jordan and Huitema, 2014c). This is because of the inherent messiness, uncertainty and intractability of climate change, and the complexities of incentives and resistance to possible responses, whether through the mitigation of climate-forcing emissions or adaptation to the impacts of climate change. There is no simple 'climate fix'. Instead a range of activities have been taken, for example, in the domains of renewable energy (Baker and Sovacool, 2017), low carbon mobility (Hopkins and Highham, 2006) and building energy demand reduction (Kivimaa and Martisikainen, 2017) with the hope of partly alleviating the problems of climate change. Awareness and knowledge of climate change is partial and contested, and incentives for action may be weak and perverse. The nature of climate change and the difficulties it poses for collective decision-making and coordination (with a global commons, blurred and differentiated responsibilities, asymmetries in costs and benefits of action, and so on) have precipitated a general search for novel forms of governance that are more exploratory, flexible and multivalent (Biermann et al., 2012; Burch et al., 2014; Hale and Roger, 2014; Jordan and Huitema, 2014a; Chan et al., 2015). Global state-led climate governance has been characterised by, for some, a disappointing record and a history of political impasses (e.g. Levin et al., 2012; Kanie et al., 2012). This record has played a role in energising the search for new ways of handling the causes and implications of climate change.

The search for and analysis of innovative forms of climate governance has been a feature of academic commentary over the past decade (Jordan and Huitema, 2014a, 2014b, 2014c; Upham et al., 2014). This includes the crafting of new governance arrangements, as well as analysis of how new modes and instruments of governance are implemented and evaluated (Huitema et al., 2011). Jordan and Huitema (2014a, 2014b) describe policy and governance innovation as significant novelty linked to the emergence of a new policy, its diffusion and effects. Part of this debate has concerned the role of experiments in generating innovations in governance, including a variety of attempts at defining climate governance experiments. Kivimaa et al. (2017:2) argue that governance experiments 'can either constitute (deliberate) interventions that aim at solving problems or developing new practices (as in pilots or demonstration projects), or they are conducted in order to learn about the effects of (limited) interventions for future (more large-scale) interventions'. Experiments can embody governance innovation but present the additional 'opportunity to tinker with new approaches, practices or institutions on a small scale and/or temporarily' (Kivimaa et al., 2017:2). It has also been argued that experimentation is less directed than innovation – often associated with the adoption of an idea in a market – and is therefore more open-ended and oriented towards exploration (e.g. Schot, Kanger and Verbong, 2016). This approach is also used in the definition of an urban sustainability experiment

developed by Sengers et al. (2016:21): ‘An inclusive, practice-based and challenge-led initiative designed to promote system innovation through social learning under conditions of deep uncertainty and ambiguity.’

The literature on climate governance (Hoffmann, 2011) has been interested in exploring novel forms of action ‘beyond, below and outside the state-dominated climate regime’ (Jordan and Huitema, 2014c). However, the analyses are often narrowly focussed on the realm of policy itself, with little consideration for the social, institutional and material aspects of governance (Bulkeley et al., 2014). Conversely, the literature on socio-technical experiments in the context of sustainability transitions (Kemp, Rip and Schot, 2001; Berkhout et al., 2010; Smith and Raven, 2012; Späth and Rohrer, 2012) has been less concerned with specific applications in policy and governance (Kivimaa et al., 2017). This gap represents a serious constraint on the broader outcomes potentially generated by experiments in governance for sustainability. Experimental initiatives tend to be situated in time and place, operate in relative isolation, and may require further refinement and consolidation to become impactful more widely. Beyond the talk of the need to *scale up*, there is little insight into how the direct outputs of experiments can be reproduced and embedded to achieve significant impact on climate change problems.

We believe that a useful next step is to define ways to harness learning from experiments with new instruments, modes and approaches to climate governance, and at the same time consider critically the shortcomings of experimentation as a solution to the wicked problem of climate change. This may be done by studying the careers of individual climate experiments and experimental practices, examining the variety of climate action on the ground, and theorising and tracking their broader outcomes on the way climate governance is done and what effects this may have at different scales of analysis.

Taking the notion of climate governance experimentation seriously, this volume focuses on the career, relevance and adequateness of climate governance experiments beyond their experimental nature, and beyond their own institutional contexts. It explores the expansion, reproduction and embedding of climate governance experiments as they turn into more than experiments.

1.1.3 Approach: Interdisciplinarity and Empirical Variety

With this volume, we have sought to capture a wide range of perspectives on climate governance experiments, reflecting the diversity of approaches proposed in the literature and in practice. It brings together contributions from a range of approaches to climate governance experiments – governance understood in the broadest sense as forms of coordination of state and society toward collective

interest (Pierre and Peters, 2005) – and to experimentation and sustainability innovation more generally. Rather than advocating for a particular view, we seek to provide a broad picture of existing concepts, representing a variety of approaches, the different challenges they identify and the main strategies they offer for governing climate change. We also seek to reflect critically on current interest in experimentation, which is far from a benign and neutral term. We find it particularly useful to mobilise rich empirical cases to support this critical line of enquiry.

We have sought to stimulate a constructive dialogue between the different approaches critically engaging with experimentation for climate governance. We have convened contributions by climate governance and innovation scholars, understood widely as studying the introduction of novelty to sociotechnical systems and the institutional and material reconfigurations that may ensue. When doing so, it became evident that other related fields are also relevant in approaching the central questions posed by ‘beyond experiments’, and this volume therefore also builds from selected approaches in science and technology studies, geography, and policy studies. This has resulted in contributions that together span a wide variety of concepts and analytical frames, providing different lenses through which to appreciate the challenges and lasting impacts of climate governance experimentation. We hope to have contributed to mapping out the contours of this intellectual space and the multiple opportunities it offers.

Rather than providing an overarching framework, our aim has been to make sense of rich and varied new directions for research, guiding contributions into a coherent direction, so as to explore the scope for cross-fertilisation. This has led us to offer a general problem framing (climate governance, experiments, embedding), a set of concepts to the problem at hand and what we see as underlying master processes (articulation and alignment at the level of systems) that each contribution deals with in specific ways. This allows us to explore a variety of current analytical contributions, unpack their significance and identify their potential complementarities. We also explore how these different conceptual frames may be ‘bridged’ (Turnheim et al., 2015).

Climate governance experimentation is rapidly evolving, presenting challenges to practitioners and researchers. For this reason, we thought it relevant to seek out a variety of interesting and novel empirical cases, focussing on their richness and diversity (see further Section 1.3). Contributions to this volume critically engage with real-world cases of climate governance experimentation, further supporting our collective exploration with empirical context and contributing to our broader conceptual ambitions. Besides obvious benefits in terms of generating inductive insights on the conduct of climate governance experiments in practice, this allows contributions to produce greater clarity about the phenomena at hand: experimentation and embedding.

1.2 Conceptual Starting Points

In this section, we start mapping out the main analytical challenges of this volume in greater detail and apply a variety of concepts to make sense of the emergent significance of experimentation in the climate governance. We recognise an inherent problem with providing strict definitions, mainly because conceptual flexibility is valuable when engaging with an emerging problem area characterised empirically by a multiplicity of entry points and because our background aim is to bring together contributions from a range of perspectives, themselves often invoking varying and incompatible conceptual tools. After more than a year of convening and mediating interdisciplinary conversations on the topic, we see our task as clarifying the range of perspectives and where they may be bridged. This implies mapping, unpacking and exposing the variety of useful perspectives, rather than reaching conceptual closure. We do so around a clear intellectual programme, which concerns understandings of experimentations, their emergence and consolidation into new ‘orders’ and the different ways in which they become embedded in practices, institutions and regimes of governance.

1.2.1 *Experimentation and Experiments*

Whereas in natural and engineering science, as well as some fields of social science like psychology and economics, the experiment is a methodological framework for testing knowledge claims against well-established criteria of significance, the notion of experimentation which we use here is significantly different. In the context of governance, experimentation is associated with more open-ended initiatives usually designed to test the feasibility or effectiveness of a novel governance practice in which emergent or unexpected outcomes may be the anticipated product. Although there is likely to be an evaluation framework for governance experiments, the process and criteria for evaluation are expected to be flexible to some extent, needing to take account of the unfolding and emergent nature of the impacts which may be observed. Typically, experiments will be expected to lead to changes, whether these relate to the pursuit of new knowledge, new practices, new solutions, or the enrolment of new actors (see Karvonen, Chapter 11; Pallett, Chapter 5). As in natural science experiments, scepticism is important to the success of governance experiments since, in practice, experiments may be mobilised to make up for the lack of more systemic action (Howlett, 2014), which can also lead to ‘reframed policy innovations’ (Upham et al., 2014). As background for the contributions to this collection, we outline a number of ways in which experimentation has been framed in existing literature, highlighting also what we see as the main focus of innovation studies and governance studies.

1.2.2 *Why Experiment? An Overview of Metaphors*

One aim of this collection is to explore the different ways in which climate governance experiments are conceived in social science. It is these ‘creation myths’ associated with experiments which will serve as the template for ideas about the broader outcomes of experiments on policy and governance. Here, we review briefly some of the main metaphors which have been employed in talking about experiments in governance and innovation studies.

Experimentation as Method: Testing Hypotheses

The term ‘experimentation’ originates from scientific method and experimental practice in laboratory contexts (see Pallett, Chapter 5). In this original form, experimentation is often inscribed within a positivist understanding of knowledge production through a primarily deductive logic, and a general understanding that a hypothesis can be formulated and then ‘tested’. In that context, experiments are seen as allowing for the testing of hypotheses through repeatable observations and the introduction of variations in a controlled setting (the laboratory). Strict controlled environments do not exist in the social realm and, hence, call for methodological adjustments in the context of climate governance (e.g. ‘uncontrolled experiments’, ‘field experiments’). An experimental approach carries with it the illusion of control over an environment, the social world and its complexity. The notion of laboratory has been transposed into the social world, in settings such as living labs (Veeckman et al., 2013), where strategic experimentation is taking place, requiring the creation of contained and to some degree ‘controlled’ spaces (Evans, 2011). Spatial and temporal bounding become central concerns (e.g. Karvonen, Chapter 11).

Experimentation as Testing: Selecting Designs that Work

Related to the preceding discussion, and against the background of classical understandings of innovation, experimentation is often seen as the initial step (e.g. ‘from theory to practice’, ‘from design to implementation’ or ‘from idea to market’). Here experimentation is seen as a means for selecting promising designs and specifying challenges on which to focus for further development. A novel idea is trialled so as to establish its feasibility, identify potential problems and guide further adjustments. This view is tied to an understanding of experimentation as a source of strategic learning to be exploited.

Experimentation is here seen as the more or less systematic testing of ideas. Within business innovation, these can be referred to as ‘trial-and-error problem-solving processes and strategies for experimentation used in the development of new products and services’ (Thomke, von Hippel and Franke, 1998:315). This

form of experimentation typically involves a simplified version of an innovative product or service and may go through a series of stages. Pilots seek to test for feasibility and acceptability, while demonstration projects aim to refine further the performance potential of an innovation (Hoogma, 2000). For highly regulated products, like pharmaceuticals, safety and efficacy testing is part of the demonstration phase. Experimenting as testing informs the notion of policy piloting, where learning can occur in a specific setting before wider deployment (see Nair and Howlett, Chapter 9; van Buuren et al., Chapter 8), or to more symbolically display leadership on a particular issue.

Experimentation as Transformational Strategy: Learning by Doing

Beyond the limits of scientific method and hypothesis testing, experiments are generally associated with the acquisition of new skills and knowledge. In such an understanding, experimentation may refer to trial-and-error learning. Learning by doing is also explicit in most definitions of experiments (Smith, 2006; Berkhout et al., 2010). Experimentation produces specific kinds of interventions, observations and inferences that may be strategically mobilised for governance purposes (Pahl-Wostl, 2009). The key aspect of experimentation becomes a process of recursive learning, which is seen as enabling improvement through iterative cycles of designing, making and adjusting (see Farrelly and Bos, Chapter 6; Karvonen, Chapter 11). Experimentation can, in this view, also be seen as a specific disposition of individuals or organisations, to be resilient under turbulent environments and is linked to notions of improvisation and organisational adaptation (Tushman and Romanelli, 1985; Weick, 1998). Therefore, learning happens both during and after experiments, on the basis of individual projects and at a more aggregate level. From our perspective of ‘beyond experiments’, learning after an experiment also appears important. In this category, higher order learning has been described as a measure of success (Brown and Vergragt, 2008) that manifests itself through, for example, changed discourses and practices, as well as policy and institutional change resulting from experimentation (Kivimaa et al., 2017).

Experimentation as Radical Novelty Creation: Opening Up Alternatives

A related metaphor understands experimentation as a source of novelty. On the one hand, such novelty can consist in relatively small variations from existing processes, offering scope for incremental improvement. On the other, radical innovation can be seen as novelty creation well beyond the boundaries of existing frameworks (of knowing, of doing, of thinking, etc.). Such a view is closely associated with an understanding that radical change tends to come from outside the prevailing ways of doing things and involves breaking conventions by experimentalists. Experimentation can then be seen as thinking beyond existing

paradigms to solve previously intractable problems, or to chart new possibilities. In a policy and governance context, this may involve seeing problems under, above and between existing jurisdictions (Jordan and Huitema, 2014c).

Experimentation as Nurturing: Fostering Alternatives in Protected Spaces

Linked to the innovation metaphor is an emphasis on the fragility and lack of ‘fitness’ of any form of novelty. Mokyr (1990) referred to path-breaking innovations as ‘hopeful monsters’ that have yet to fulfil their potential and may carry a number of intrinsic problems. From this comes the idea that experiments are organised for nurturing and protecting early and vulnerable seeds of change. Experiments are seen as small-scale initiatives in the earliest stages of innovation processes that do not yet conform to existing socio-technical contexts (Schot, Hoogma and Elzen, 1994; Berkhout et al., 2010). Due to their inherent fragility, new socio-technical configurations can be strategically nurtured in ‘niches’ (cf. Kemp et al., 2001), understood as ‘protected spaces’ where external selection pressures cannot exert their full influence (Smith and Raven, 2012). Within this evolutionary understanding of change, experimentation is seen as an activity enabling a variety of options and solutions to be generated and their relevance explored. This view sees a role for experimentation in an understanding of transformative change that originates from and grows in innovation niches, and eventually may break through to challenge (and overtake) an established regime.

Experimentation as Politics: Performing Reality

Experimentation is not a value-free proposition. On the contrary, engaging with the world through experimentation is reminiscent of the generalisation of a scientific method to all realms of society – in our case climate governance. However open or narrow the transposition of the laboratory metaphor to the social realm, experimentation has a performative dimension with deep implications. Experimentation implies the appreciation and acceptance of a worldview and a set of tools, mobilised to produce collective realities (see Castán Broto and Bulkeley, Chapter 4). In short, experimentation can be seen as a process of ordering the socio-material world. The experimental process and its concrete outputs, by articulating and establishing a certain kind of reality, define what is important and worth observing, make predictions about broader outcomes and seek to validate these through actions. An experimental attitude contributes to ‘governing’ the perceptions and actions of individual actors and decision-makers by, for instance, favouring certain approaches over others, legitimising certain forms of epistemic authority and permitting and preventing access of certain actors. In this sense, experimentation can be seen as ‘politics by other means’. This becomes

salient when knowledge generated by experiments is mobilised to support or justify specific political decisions. Looking at experimentation from this perspective enables a critical and reflexive appreciation of experimental settings, with attention to the normative, political and cultural implications of climate governance experiments. It may open up to alternative ways of handling experimentation beyond disciplined, authoritative and exclusive procedures for knowledge generation. This view of experimentation can also be empowering insofar as it supports the possibility for reordering collective realities.

This overview of understandings and metaphors of experimentation provides a range of narratives for our exploration of experimentation in climate governance. Experiments are associated with hopeful promises, carry a novelty value, are inherently fragile, tentative and temporary, are often mobilised instrumentally and also denote a certain creative capacity to envision alternative ways of seeing, doing and valuing. Experimentation is often inscribed in a wider frame of innovation – whether this is motivated by a discourse of ‘betterment’, a logic of continuous adaptation to changing realities or less instrumental perspectives on change. Proposing experimentation as a legitimate approach to governance calls into question the motives, supporting narratives and expectations, as well as models of change being invoked. It may be wise to remain on your guard when scholars start speaking about experiments.

1.2.3 A Dialogue between Studies of Governance and Innovation Studies

A number of insights have informed the design of this collection. First, the observation that while research on climate governance has increasingly come to frame a concern around the *innovation* of new modes and instruments of governance (Jordan and Huitema, 2014b), it has not engaged in any deep way with the perspectives that have emerged over the past fifty years or so in economics, sociology and history on the role of new knowledge and technology in the economy and society more broadly. Second, the observation that contemporary innovation studies concerned with *socio-technical* change often take an unnuanced view of policy and governance and appear to have had little impact on the practice of policy and governance. There appears to be room to learn from scholars of government and governance. Third, both traditions have shown a marked interest in experiments, whether these are experiments in governance (Sabel and Zeitlin, 2012; McFadgen and Huitema, 2016) or experiments (or niches) as sources of radical novelty leading to wider socio-technical change (Kemp, Schot and Hoogma, 1998; Seyfang and Smith, 2007; Smith and Raven, 2012; Seyfang et al., 2014). In both traditions there has been an interest in the role of ‘outsider’ and radical actors in generating new ideas and ways of doing things,

and how these activities can be nurtured and protected so that they can prove their value over the longer term.

Finally, both traditions have not been interested in experiments in their own right, but primarily as a source of alternatives which may come to challenge and overturn dominant paradigms and practices. For both governance and innovation studies, the interest in experiments has therefore ultimately been about how the concrete outputs of experiments may generate broader impact on the governance or socio-technical systems which they address. This may be through the adoption of ideas, through the translation of skills and capabilities or through a deeper reordering of norms and institutional rules and arrangements. So it is clear that the two traditions have much to say to each other. Climate governance studies may be enriched by insights from innovation studies, and the flow of ideas in the other direction may be just as fruitful. Here we provide a sketch of the main analytical frames mobilised in innovation studies and governance studies, suggesting how they may contribute to the research agenda, and what the potential for cross-fertilisation is.

Innovation Studies

Innovation studies is concerned with the role of science, technology and innovation in economies and societies and draws on a range of disciplines including economics, history, science and technology studies, sociology and cultural studies. Classical work on innovation (Freeman, Clark and Soete, 1982; Freeman and Louça, 2001; Fagerberg, 2004) distinguishes between radical technical change through sustained search and experimentation with alternatives and incremental change through trial-and-error processes and learning-by-doing in which tacit and practical knowledge are built up about new ways of doing things (van de Ven et al., 1999).¹ Emphasis is placed on the combination of resources (knowledge, skills, networks and material resources) with sufficient freedom and openness to create opportunities for novelty, while balancing the need for continuity and stability in production and consumption systems.

Risk, uncertainty, surprises and failures are viewed as intrinsic to innovative processes and explain the behaviour of actors involved in these processes, whether they are innovators or adopters of innovations. This points to the risks innovation poses for established actors – whether these are firms, public organisations or societal organisations – and explains why experiments often originate from newcomers and marginal actors. This relates to deeper debates about

¹ These trial-and-error processes may also be regarded as experimental, leading to a bifurcation in the understandings of experimentation in innovation studies: first as organised processes of disruptive or radical innovation, and second as a generalised process leading to incremental innovation.

innovation which we can roughly trace as a progression away from linear models (from science to R&D to innovation) emphasising the development of technological knowledge, towards a greater interest in innovation within socio-technical systems in which norms, rules and social relationships are always embedded in and shaped by material technologies (Geels, 2002, 2005; Smith, Stirling and Berkhout, 2005). This new wave of innovation studies, which is interested in larger-scale system innovation over the long run, also takes a broader view of socio-technical systems as ‘configurations that work’ (Rip and Kemp, 1998).

Classical studies of innovation diffusion draw heavily on the work of Rogers (1962) who viewed diffusion as a communication process between members of a social system, leading to the development of an ‘epidemic model’ of adoption and diffusion. Rogers and subsequent contributions (Von Hippel, Thomke and Sonack, 1999) argued that adoption includes a measure of reinvention or further adaptation and the ‘fitting’ of innovations to user needs and practices. In this sense, adoption and diffusion must be seen as an integral part of the innovation process. Nevertheless, it can be argued that innovation studies generally have an under-theorised approach to processes of adoption, diffusion and transferability of innovations, whether technical or organisational.

Socio-technical innovation studies argue that experimentation, as a distributed and problem-oriented search process, requires enabling environments, systems and institutions (Hekkert et al., 2007; Smith, Voss and Grin, 2010). Strategic Niche Management (Kemp et al., 1998; Kemp et al., 2001), for instance, argues that ‘protected spaces’ are needed for experimental activities to develop into more stable configurations (Smith and Raven, 2012) to be able to overturn incumbent socio-technical regimes. Communication alone does not explain the processes of adoption and adaptation that occur as new ways of doing things are diffused more broadly. Instead the enabling role of collective learning and knowledge development, new networks and alliances that convene disparate interests, and the definition of shared goals, norms and expectations are significant in bringing about a reconfiguration of a broader socio-technical system, hence ‘system innovation’.

Governance and Policy Studies

Dating back to the 1950s (Hoppe, Coenen and van den Berg, 2016), governance and policy studies can broadly be defined to contain the disciplines of political science, public administration, economics and legal studies, among others. Policy studies are focused on the content, processes and effects of government policies in their surrounding social and political contexts (Hoppe et al., 2016) while governance studies are broader, with interest in the governing activities of social,

economic, political and administrative actors (Kooiman, 2003) and articulations of policy, politics and polity (Lange et al., 2013). As with innovation studies, governance studies draw from multiple theories and literature to study structures, mechanisms and policies in place, as well as the processes by which they unfold and influence real or potential impacts. The latter is particularly addressed in studies of policy evaluation and appraisal – that have not considered the evaluation of policy innovations or experiments explicitly.

Governance and policy studies have come to experimentation with an interest in *responses*, *solutions* and *arrangements* that do not readily fit pre-existing policy channels (e.g. Sabel and Zeitlin, 2010), or which emerge in response to fragmented political orders and authorities, as is the case with ‘climate experiments’ (Hoffmann, 2011). There is a recognition of the limitation of traditional models of evidence-based governance in the face of ‘wicked’ problems and their associated uncertainties and incentive problems.

Two main views seem to co-exist and overlap. On the one hand, experimentation is seen as a structured process of search initiated by institutionally situated actors. ‘Policy experiments’ are seen as pilots, typically upstream from a process that may lead to policy innovation. This transfer is often unsuccessful because of the difficulty to ‘scale up’ or ‘diffuse’ new ideas and arrangements (Vreugdenhil, Taljaard and Slinger, 2012). Such difficulties may arise from a lack of willingness to address more fundamental problems (Howlett, 2014). Experiments may also significantly challenge established ways of doing and evaluating policy (Martin and Sanderson, 1999).

On the other hand, experimentation may be seen as a means for ‘shaking up’ governance arrangements around new narratives, logics, interests, incentive structures and evaluation schemes, as witnessed in recent enthusiasm about the role of bottom-up, voluntary and entrepreneurial non-state climate action (Jordan et al., 2015), and in the research focus on climate experiments (Abbott, 2012; Bulkeley et al., 2012). Climate governance experiments have been framed as alternate means of responding or attending to climate change (Hoffmann, 2011), contrasting with the more formal governance regimes of international agreements, with targets and coordination mechanisms codified in law. These local climate governance experiments may provide space and mandates for new actors (e.g. the city) to lead on generating situated solutions to collective action problems, tapping into grassroots energy and ingenuity. Within this latter view, experimentation has become associated with emerging centres of authority and governance that are inherently more distributed and networked (polycentrism) and with alternative ways of achieving coordinated action that are more tentative, emergent and self-organising and that avoid the costs and rigidities of centralised coordination.

1.2.4 Beyond Experiments: What Are the Outputs of Experiments and What Influence Do They Have?

We want to understand experiments in terms of their wider impacts once the experimental phase is over and to explore experimentation as a practice for generating changes in climate governance. For this reason, we seek to understand the *becoming* of climate governance experiments, in search of what are their outputs that may be communicated, reproduced and embedded beyond particular experiments themselves, thus, generating broader outcomes. We are interested in the processes by which experiments may become relevant from a systemic perspective.

We also believe that a focus on ‘beyond experiments’ enables us to articulate a number of important tensions of relevance to experimentation as a way forward to address climate governance challenges. Our interest in ‘beyond’ – preposition, adverb and noun – is tied to its potential to generate critical analysis. In this respect we see ‘beyond’ as taking up different meanings:

- **A temporal** dimension which can be summarised as ‘after’. Along this dimension, we are interested in the fate of the concrete outputs of experiments (ideas, norms, people and ways of doing things), starting from the well-documented observation that governance experiments are usually short-lived, often abandoned as political priorities change or a cycle of funding ends, as are their legacies. So, we ask whether experiments can be sustained through time. This relates to the ‘longevity’ of governance experiments as well as to deeper changes that may emerge from experimentation processes. In this second temporal sense, we are interested in the broader outcomes and implications of experiments, whether this is seen as learning, conceptual or hypothesis testing, network and alliance formation, the opening of new development paths and so on. We also link this back to a question about stability and change in innovation studies. The temporal dimension justifies a need for more critical analyses of the long-term life and effects of climate governance experimentation.
- **A spatial** dimension which articulates the tension between the situated nature of individual experiments and expectations about more generic and transferable outcomes of experimentation. This relates to the questions about whether experiments and their concrete outputs can be sustained across different scales and spaces. If we look beyond individual experiments, we see a variety of processes by which the outputs of experiments can become mobile, affecting their contributions to transformative change.
- **An evaluative** dimension which links back to the pragmatic justification for experimentation as a new means of governing (experimental governance). Questions here concern common evaluation criteria (e.g. relevance,

effectiveness, efficiency and coherence), as well as new questions related to scaling or mainstreaming or the cumulative effects of experimentation (or, in other words, how experimental governance initiatives may ‘add up’ and substantially contribute to the long-term mitigation of climate change). We believe this evaluative dimension to also be crucial in terms of critically addressing the ‘success’ in experimentation, and the extent to which ‘failure’ may be equally (if not more) valuable in terms of learning from experimentation – a common theme in innovation studies. We would like to confront the idea that experimentation always leads to broader positive outcomes by, for instance, attending to the proponents of experimentation in climate governance and their motivations.

In short, we believe that a satisfactory account of experiments would deal with the temporal and spatial boundaries of an experiment, beyond which it has broader influence, and with the criteria that are being used to judge and value that influence.

1.2.5 Diffusion of Experimental Outputs as a Process of Embedding

In searching for a single concept to capture the wide variety of ways in which the outputs of experiments may have a wider influence, we have chosen to employ the concept of embedding. We search for a concept of mobility, expansion and diffusion of experimental outputs that combines a notion of transfer and exchange with a conception of the broader institutional, political and normative settings that may be transformed by these transfers and which, in turn, respond to such exchange. We want to develop an idea of embedding that responds to the core notion of a governance system as a configuration of rules, responsibilities, values and outcomes that works, and which to some extent comes to be reworked or reconfigured as a result of its response to the outputs of experiments. Outcomes are not unidirectional, but always a derivative of a further interplay of new and existing ideas and practices. We hope to demonstrate with this volume that experiments become relevant if and as they engage with the challenge of their embedding – something that is often lacking in practice but for which we can already derive some guiding insights and lessons.

Embedding as Object of Research: Why Focus on Embedding?

We argue that despite a growing interest in experimentation in general and for climate governance more specifically, comparatively less attention has been paid to governance *after and beyond* the scope of experiments. Focussing on the embedding of experiments enables us to capture a specific ‘moment’ and ‘site’ for innovation in society: the acquisition of momentum and wider relevance of

individual initiatives. Given that experimentation is increasingly seen as a solution to overcome lock-in and path dependencies that prevent effective climate change mitigation and its governance, we need to further understand the actual outputs of climate experiments, their implications and the processes by which experimental outputs become embedded and create more lasting outcomes in society.

Broadening the Understanding of Embedding

Theories of embeddedness take their rooting in the field of economic history (Polanyi, 2001) and economic sociology (Granovetter, 1985) as a way to problematise the influence of wider social environments on, in these circumstances, economic activity. In this context, economic activity is understood as ‘embedded’ in a wider set of social institutions and relationships. Long-term economic change goes hand in hand with concomitant institutional change and their mutual embedding. Generalising from this view, embeddedness can be applied to any sphere of social exchange as a way of understanding its relationship to the wider social, institutional and cognitive environments in which they operate. Embedding and embeddedness have taken up a significant importance in innovation studies, where ‘societal embedding’ is seen as a process of mutual shaping and adjustment between innovation and its wider context (Leonard-Barton, 1988; Nye, 1998; Rip and Kemp, 1998; Boschma, Lambooy and Schutjens, 2002).

Embeddedness can be thought of as a form of interdependence and connectivity between activities, structures and contexts. In the frame of system innovation, embedding can be seen as a process of articulation and alignment of experiments in conjunction with wider institutional or cultural settings. This can be operationalised at different levels and across multiple dimensions.

Embedding Climate Governance Experimentation

The embedding of climate governance experiments captures a process by which experiments become more than experiments, for example, by encouraging the wider uptake of a new approach, by informing the establishment of new forms of governance, by entering mainstream discourses and practices, by prefiguring wider transformation, by challenging established ways of doing and so on. What we mean by *embedding* is a process by which governance experiments develop or influence beyond the initial context within which a new way of doing things has been configured, involving a recasting of its scope and enrolling new agents into the project of performing an alternative mode or method of governing, and through such a process transforming climate governance itself. Not all experiments become embedded, and it is important to pay more attention to the extent to which experiments meet their claim in achieving the impacts they are intended or envisioned to achieve.

Given this broad understanding of embedding within the context of climate change governance, a number of views about the main processes involved can be distinguished. These differ in terms of the core mechanisms, temporalities, scales, institutional dynamics and agents of change that they mobilise. The contributions to this volume offer a range of different perspectives of embedding, and underlying models of change, which we summarise and discuss in the concluding chapter to this volume.

1.3 Contributions to This Volume

1.3.1 Overview

Chapters in this volume provide an indication of the breadth of research concerned with the role of experiments in climate governance and their contribution to climate change mitigation and adaptation. They provide an impression of the variety of climate governance experimentation on the ground, with particular emphasis on non-state local action, and the different ways in which this is contributing to and challenging state-led climate governance practices. While an edited volume can only cover a part of this expanding domain, the chapters cover substantial empirical territory (see Table 1.1): a wide range of cases in several countries and spanning all the major continents. They show a balance between concerns of climate adaptation (responding to the impacts of changing climate and variability) and mitigation (reducing emissions of greenhouse gases to the atmosphere). Many chapters illustrate examples of experimentation and beyond, predominantly in the energy and water management domains, but also in buildings, urban regeneration, agriculture and participatory knowledge production.

Given the dominance of urban issues in recent research on climate governance experimentation (evidenced by the growing influence of networks such as ICLEI and C40 on climate issues), it is not surprising that many chapters place emphasis on local urban and municipal scales. However, the volume also looks at national and international governance regimes and covers interactions across different levels of governance.

In conceptual terms, the contributions span a broad spectrum of ways of thinking about experiments, their concrete outputs and their broader outcomes, including the establishment of experimentation as a mainstream logic for governance. In this way, the collection of chapters meets our goal to examine a range of takes on what can happen after an experimental stage. In our efforts to consider productive interactions between governance studies and innovation studies to examine this topic, we also mobilised contributions from neighbouring fields, including urban and economic geography and transitions studies. In addition, some

Table 1.1. *Comparative overview of empirical book contributions (Chapters 3–11)*

	Authors	Cases			IPCC			Scale			Literature					Lead actor				
		Initiatives	Country	Domain	Adaptation	Mitigation	Municipal	Urban	National	Multilevel	Time frame	Governance	Innovation	Transitions	Geography	Other	Policy	Civil society	Research	Private
3	Carvalho and Lazzerini	PT, IT	Multiple in 6 states	US	Electricity	•	•	•	•	•	1997–2016	•	•	•	•	•	•	•	•	•
4	Castán Broto and Bulkeley	UK	8	IN, MEX, US, ZA, DE, BR, HK, UK	Multiple	•	•	•	•	•	•	•	•	•	STS	•	•	•	•	
5	Pallett	UK	Multiple	UK	Multiple (science)	n/a	n/a	•	•	•	2000–today	•	•	•	STS	•	•	•	•	•
6	Farrelly and Bos	AUS	Multiple	AUS	Buildings, water	•	•	•	•	•	1990s–today	•	•	•	•	•	•	•	•	•
7	Hölscher et al	NL	Multiple	NL	Energy, water mgmt.	•	•	•	•	•	2005–today	•	•	•	•	•	•	•	•	•
8	Van Buuren et al	NL	11 pilots	NL, DE	Water mgmt.	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
9	Nair and Howlett	SG, US	14	IN	Agriculture	•	•	•	•	•	1990–today	•	•	•	Policy analysis	•	•	•	•	•
10	Heiskanen and Matschoss	FI	2	FI	Multiple	•	•	•	•	•	•	•	•	•	Evaluation	•	•	•	•	•
11	Karvonen	UK	Multiple	n/a	Unspecified	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

of the chapters touch on more ‘specialised’ theoretical perspectives. They build on influences derived from Science and Technology Studies (STS), policy evaluation, field theory, resilience theory, participation and democratic theory, assemblage and urban metabolism. The contributions in this volume bear witness to the range of relevant theories and approaches to studying climate governance experiments and their embedding (see Table 1.1).

In terms of the empirical contributions, the chapters present illustrative cases of experiments and their embedding within a relatively recent time frame, focussing on the 1990s onwards, with most cases covering the past ten to fifteen years. This temporal focus reflects the strong momentum of climate experimentation in the field in recent years. Similarly, while representing all world regions, a significant proportion of the evidence discussed in this volume is drawn from Northern European countries. This focus reflects an empirical reality, as climate governance experimentation remains an emerging phenomenon shaped by public discourses in that part of the world – with, for instance, the Netherlands and Finland playing a particularly visible role in institutionalising this experimental stance.

1.3.2 *Structure of This Volume*

We have chosen to organise this volume in two parts, reflecting broad motivations for climate governance experimentation, namely *exploration* and *transformation*. Because these are inherently intertwined, most contributions are relevant to both aspects. Nonetheless, the contributions tend to emphasise one over the other, which reflects the inherent dilemma that their joint pursuit involves in practice.

Part I Experiments: Exploring Innovations in Climate Governance

Climate governance experiments have the potential to open up new ways of attending to and living with the challenges of climate change. Part I focuses on the conduct of climate governance experiments, how and where experimentation takes place, who participates, the various formats of experimentation, its exploratory nature and the kinds of direct and indirect outputs generated. It does so by mobilising rich case studies and multi-case comparisons of climate governance experimentation in practice. We are interested in better understanding the range of broader outcomes of experiments that extend beyond their original setting, and how they can contribute to the crafting of more durable alternatives. Within this frame, the kinds of knowledge and experiences arising from climate change experiments as they become exploitable, transferable or scalable beyond their original application context are explored. This leads us to focus on mechanisms supporting the shift from situated climate governance experiments to more generic

and mobile alternatives that can gain traction in a variety of contexts. Beyond experiments are new territories for their embedding.

Part II Beyond Experiments: Transforming Climate Governance

Climate governance experiments, beyond enabling exploration and the search for alternative ways of doing, can have profound effects on governance arrangements themselves and the socio-technical systems in which they are embedded. Part II focuses on the transformative outcomes of governance experiments, as their proliferation challenges and reconfigures governance structures and processes in place. This leads us to focus on how climate governance experiments are taken up in existing climate governance regimes and how climate experiments transform governance and other milieus through which they pass. Embracing climate experimentation as a new *modus operandi* calls for new (e)valuations of success and reinventing the craft of climate governance and decision-making altogether. We ask what climate governance may look like if it becomes reconfigured around the opportunities and promises deriving from the handling of experimentation. Beyond experiments are uncharted territories for climate governance.

1.4 Conclusion

This volume has been designed to provide an exploration of the range of conceptual approaches to the embedding of experiments leading to innovations in climate governance, each foregrounding specific patterns, mechanisms, roles, strategies, tensions and opportunities. By presenting a variety of perspectives, we hope to enrich an understanding of the possible avenues for climate governance experimentation. This kind of novel cross-fertilisation between perspectives can generate important lessons for understanding the dynamics of innovation in climate governance arrangements and experiments in particular, with the aim of contributing to effective strategies for addressing the serious societal risks associated with global climate change.

We bring together a number of rich and original empirical contributions, in-depth case studies and more comparative approaches. Together, we hope that they convey the variety of contexts in which climate governance experimentation is being pursued, contribute to the understanding of how experiments are becoming embedded across a variety of contexts and, thus, feed into both experimental designs where embedding is regarded from the outset and institutional designs that encourage and make room for the outcomes of experiments.

As the search for new governance responses to climate change accelerates, we are likely to see more experiments. So we need to be equipped: remain critical as to motivations, recognise an increasingly distributed and polycentric governance

landscape, introduce clarity of objectives and evaluation and develop pathways to learning and competence building. We want a situated analysis of the mobility and influence or a variety of possible outputs of experiments and the challenge they pose to sense-making, positionalities, values and the constitution of orders. We want to explore experiments as a precursor to generalising ways of doing things and the potential of experimentalism as a governance approach in its own right.

Clarifying and mobilising the idea of embedding experiments is a major conceptual challenge. There are different understandings of this process. Conventionally these have included theories of diffusion and the idea of ‘upscaling’. Diffusion has been formalised in a variety of ways in innovation and governance studies, while upscaling has been much less well theorised. We do not prescribe one over others. However, we do want to develop an argument that argues that innovation – developing a new ways of doing things – requires a process of rule-making and practical *embedding* that includes both the modification of the new, as well as the reconfiguration of existing systems. Embedding is, therefore, a mutual process of adaptation of novelty and of the governance context within which innovations flowing from governance experiments become embedded. This process will follow context-specific and historical patterns.

References

- Abbott, K. W. (2012). The transnational regime complex for climate change. *Environment and Planning C: Government and Policy*, 30(4), 571–590.
- Baker, L., and Sovacool, B. K. (2017). The political economy of technological capabilities and global production networks in South Africa’s wind and solar photovoltaic (PV) industries. *Political Geography*, 60, 1–12.
- Berkhout, F., Verbong, G., Wieczorek, A. J., Raven, R., Lebel, L., and Bai, X. (2010). Sustainability experiments in Asia: Innovations shaping alternative development pathways? *Environmental Science & Policy*, 13(4), 261–271.
- Biermann, F., Abbot, K., Andresen, S., Backstrand, K., Bernstein, S., et al. (2012). Transforming governance and institutions for global sustainability: Key insights from the Earth System Governance Project. *Current Opinion in Environmental Sustainability*, 4(1), 51–60.
- Blok, A., and Tschötschel, R. (2016). World port cities as cosmopolitan risk community: Mapping urban climate policy experiments in Europe and East Asia. *Environment and Planning C: Government and Policy*, 34(4), 717–736.
- Boschma, R. A., Lambooy, J. G., and Schutjens, V. (2002). Embeddedness and innovation. In Tayloer, M., and Leonard, S. (eds.), *Embedded Enterprise and Social Capital*. Aldershot: Ashgate, 19–37.
- Broto, V. C., and Bulkeley, H. (2013). A survey of urban climate change experiments in 100 cities. *Global Environmental Change*, 23(1), 92–102.
- Brown, H. S., and Vergragt, P. J. (2008). Bounded socio-technical experiments as agents of systemic change: The case of a zero-energy residential building. *Technological Forecasting and Social Change*, 75(1), 107–130.

- Bulkeley, H., Andonova, L., Bäckstrand, K., Betsill, M., Compagnon, D., et al. (2012). Governing climate change transnationally: Assessing the evidence from a database of sixty initiatives. *Environment and Planning C: Government and Policy*, 30(4), 591–612.
- Bulkeley, H. A., Broto, V. C., and Edwards, G. A. S. (2014). *An Urban Politics of Climate Change: Experimentation and the Governing of Socio-technical Transitions*. London: Routledge.
- De Búrca, G., Keohane, R. O., and Sabel, C. (2014). Global experimentalist governance. *British Journal of Political Science*, 44(3), 477–486.
- Burch, S., Shaw, A., Dale, A., and Robinson, J. (2014). Triggering transformative change: A development path approach to climate change response in communities. *Climate Policy*, 14(4), 467–487. doi: 10.1080/14693062.2014.876342.
- Chan, S., van Asselt, H., Hale, T., Abbott, K. W., Beisheim, M., et al. (2015). Reinventing international climate policy: A comprehensive framework for effective nonstate action. *Global Policy*, 6(4), 466–473.
- Dryzek, J. S. (1987). *Rational Ecology: Environment and Political Economy*. New York: Basil Blackwell.
- Evans, J. P. (2011). Resilience, ecology and adaptation in the experimental city. *Transactions of the Institute of British Geographers*, 36(2), 223–237.
- Fagerberg, J. (2004). Innovation: A guide to the literature. In J. Fagerberg, D. C. Mowery, and R. R. Nelson (eds.), *The Oxford Handbook of Innovation* (pp. 1–26). Oxford: Oxford University Press.
- Freeman, C., Clark, J., and Soete, L. (1982). *Unemployment and Technical Innovation: A Study of Long Waves and Economic Development*. London: Pinter.
- Freeman, C., and Louça, F. (2001). *As Time Goes By*. Oxford: Oxford University Press.
- Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy*, 31, 1257–1274. doi: 10.1016/S0048-7333(02)00062–8.
- Geels, F. W. (2005). Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. *Technological Forecasting and Social Change*, 72(6), 681–696. doi: 10.1016/j.techfore.2004.08.014.
- Granovetter, M. (1985). Economic action and social structure: The problem of embeddedness. *American Journal of Sociology*, 91(3), 481–510.
- Greenberg, D. H., Links, D., and Mandell, M. (2003). *Social Experimentation and Public Policymaking*. Washington, DC: The Urban Institute Press.
- Hale, T., and Roger, C. (2014). Orchestration and transnational climate governance. *Review of International Organizations*, 9(1), 59–82.
- Hekkert, M. P., Suurs, R., Negro, S., Huhlmann, S., and Smits, R. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social Change*, 74(4), 413–432.
- Von Hippel, E., Thomke, S., and Sonnack, M. (1999). Creating breakthroughs at 3M. *Harvard Business Review*, 77, 47–57.
- Hoffmann, M. J. (2011). *Climate Governance at the Crossroads: Experimenting with a Global Response after Kyoto*. Oxford: Oxford University Press.
- Hoogma, R. (2000). *Exploiting Technological Niches: Strategies for Experimental Introduction of Electric Vehicles*. Enschede: Twente University Press.
- Hopkins, D., and Higham, J. (eds.). (2016). *Low Carbon Mobility Transitions*. Oxford: Goodfellow Publishers.
- Hoppe, T., Coenen, F., and van den Berg, M. (2016). Illustrating the use of concepts from the discipline of policy studies in energy research: An explorative literature review. *Energy Research and Social Science*, 21, 12–32.

- Howlett, M. (2014). Why are policy innovations rare and so often negative? Blame avoidance and problem denial in climate change policy-making. *Global Environmental Change*, 29, 395–403. doi: 10.1016/j.gloenvcha.2013.12.009.
- Huitema, D., Jordan, A., Massey, E., Rayner, T., van Asselt, H., et al. (2011). The evaluation of climate policy: Theory and emerging practice in Europe. *Policy Sciences*, 44(2), 179–198.
- Jordan, A., and Huitema, D. (2014a). Innovations in climate policy: Conclusions and new directions. *Environmental Politics*, 23(5), 906–925. doi: 10.1080/09644016.2014.924209.
- Jordan, A., and Huitema, D. (2014b). Innovations in climate policy: The politics of invention, diffusion, and evaluation. *Environmental Politics*, 23(5), 906–925.
- Jordan, A., and Huitema, D. (2014c). Policy innovation in a changing climate: Sources, patterns and effects. *Global Environmental Change*, 29, 387–394.
- Jordan, A., Huitema, D., van Asselt, H., Rayner, T., and Berkhout, F. (2010). *Climate Change Policy in the European Union: Confronting the Dilemmas of Mitigation and Adaptation?* Cambridge: Cambridge University Press.
- Jordan, A. J., Huitema, D., Hildren, M., van Asselt, H., Rayner, T. J., et al. (2015). Emergence of polycentric climate governance and its future prospects. *Nature Climate Change*, 5(11), 977–982. doi: 10.1038/nclimate2725.
- Kanie, N., Betsill, M. M., Zondervan, R., Biermann, F., Young, O. R. (2012). A charter moment: Restructuring governance for sustainability. *Public Administration and Development*, 32(3), 292–304.
- Kemp, R., Schot, J., and Hoogma, R. (1998). Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis & Strategic Management*, 10(2), 175–198.
- Kemp, R. P. M., Rip, A., and Schot, J. W. (2001). Constructing transition paths through the management of niches. In Garud, R., and Karnoe, P. (eds.), *Path Dependence and Creation*. Mahwah, NJ: Lawrence Erlbaum Associates, 269–299.
- Kivimaa, P., Hildén, M., Huitema, D., Jordan, A., and Newig, J. (2017). Experiments in climate governance: A systematic review of research on energy and built environment transitions. *Journal of Cleaner Production*, 169: 17–29.
- Kivimaa, P., and Martiskainen, M. (2017). Innovation, low energy buildings and intermediaries in Europe: systematic case study review. *Energy Efficiency*, 1–21.
- Kooiman, J. (2003). *Governing as Governance*. London: Sage.
- Lange, P., Driessen, P. P. J., Sauer, A., Bornemann, B., and Burger, P. (2013). Governing towards sustainability: Conceptualizing modes of governance. *Journal of Environmental Policy and Planning*, 15(3), 403–425.
- Leonard-Barton, D. (1988). Implementation as mutual adaptation of technology and organization. *Research Policy*, 17(5), 251–267. doi: 10.1016/0048-7333(88)90006-6.
- Levin, K., Cashore, B., Bernstein, S., and Auld, G. (2012). Overcoming the tragedy of super wicked problems: Constraining our future selves to ameliorate global climate change. *Policy Sciences*, 45(2), 123–152. doi: 10.1007/s11077-012-9151-0.
- Martin, S., and Sanderson, I. (1999). Evaluating public policy experiment: Measuring outcomes, monitoring processes or managing pilots. *Evaluation*, 5(3), 245–258.
- McFadgen, B., and Huitema, D. (2017). Are all experiments created equal? A framework for analysis of the learning potential of policy experiments in environmental governance. *Journal of Environmental Planning and Management*, 20(10) 1–20.
- McFadgen, B., and Huitema, D. (2017). Experimentation at the interface of science and policy: A multi-case analysis of how policy experiments influence political decision-makers. *Policy Sciences*, 1–27. doi: 10.1007/s11077-017-9276-2

- Mokyr, J. (1990). *The Lever of Riches: Technological Creativity and Economic Progress*. New York: Oxford University Press.
- Nye, D. E. (1998). *Consuming Power: A Social History of American Energies*. Cambridge, MA: MIT Press.
- Ostrom, E. (2010). Beyond markets and states: Polycentric governance of complex economic systems. *American Economic Review*, 100(3), 641–672. doi: 10.1257/aer.100.3.641.
- Pahl-Wostl, C. (2009). A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change*, 19(3), 354–365.
- Pierre, J., and Peters, B. (2005). *Governing Complex Societies: Trajectories and Scenarios*. Basingstoke and New York: Palgrave Macmillan.
- Polanyi, K. (2001). *The Great Transformation: The Political and Economic Origins of our Time*. London: Beacon.
- Renn, O., Klinke, A., and van Asselt, M. (2011). Coping with complexity, uncertainty and ambiguity in risk governance: A synthesis. *Ambio*, 40(2), 231–246.
- Rip, A., and Kemp, R. (1998). Technological change. In Rayner, S., and Malone, L. (eds.), *Human Choice and Climate Change*, Vol. 2, *Resources and Technology*. Washington, DC: Batelle Press, 327–399.
- Rogers, E. M. (1962). *Diffusion of Innovations*. New York: Free Press of Glencoe.
- Sabel, C. F., and Zeitlin, J. (2010). Learning from difference: The new architecture of experimentalist governance in the EU. In Sabel, C. F., and Zeitlin, J. (eds.), *Experimentalist Governance in the European Union: Towards a New Architecture*. Oxford: Oxford University Press, 1–28.
- Sabel, C. F., and Zeitlin, J. (2012). Experimentalist governance. In Levi-Faur, D. (ed.), *The Oxford Handbook of Governance*. Oxford: Oxford University Press.
- Schot, J., Hoogma, R., and Elzen, B. (1994). Strategies for shifting technological systems: The case of the automobile system. *Futures*, 26(10), 1060–1076.
- Schot, J., Kanger, L., and Verbong, G. (2016). The roles of users in shaping transitions to new energy systems. *Nature Energy*, 1(5), 16054. doi: 10.1038/nenergy.2016.54.
- Sengers, F., Berkhout, F., Wieczorek, A. J., and Raven, R. (2016). Experimenting in the city: Unpacking notions of experimentation for sustainability. In Evans, J., Karvonen, A., and Raven, R. (eds.), *The Experimental City*. London and New York: Routledge, 15–31.
- Seyfang, G., Hielscher, S., Hargreaves, T., Martiskainen, M., Smith, A. (2014). A grassroots sustainable energy niche? Reflections on community energy in the UK. *Environmental Innovation and Societal Transitions*, 13, 21–44. doi: 10.1016/j.eist.2014.04.004.
- Seyfang, G., and Smith, A. (2007). Grassroots innovations for sustainable development: Towards a new research and policy agenda. *Environmental Politics*, 4016(4), 37–41. doi: 10.1080/09644010701419121.
- Smith, A. (2006). Green niches in sustainable development: The case of organic food in the United Kingdom. *Environment and Planning C: Government and Policy*, 24(3), 439–458. doi: 10.1068/c0514j.
- Smith, A., and Raven, R. (2012). What is protective space? Reconsidering niches in transitions to sustainability. *Research Policy*, 41(6), 1025–1036. doi: 10.1016/j.respol.2011.12.012.
- Smith, A., Stirling, A., and Berkhout, F. (2005). The governance of sustainable socio-technical transitions. *Research Policy*, 34(10), 1491–1510. doi: 10.1016/j.respol.2005.07.005.

- Smith, A., Voss, J. P., and Grin, J. (2010). Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy*, 39(4), 435–448. doi: 10.1016/j.respol.2010.01.023.
- Späth, P., and Rohrer, H. (2012). Local demonstrations for global transitions: Dynamics across governance levels fostering socio-technical regime change towards sustainability. *European Planning Studies*, 20(3), 461–479.
- Tassey, G. (2014). Innovation in innovation policy management: The Experimental Technology Incentives Program and the policy experiment. *Science and Public Policy*, 41(4), 419–424.
- Thomke, S., von Hippel, E., and Franke, R. (1998). Modes of experimentation: An innovation process – and competitive – variable. *Research Policy*, 27(3), 315–332. doi: 10.1016/S0048-7333(98)00041-9.
- Turnheim, B., Berkhout, F., Geels, F., Hof, A., McMeekin, A., Nykvist, B., and van Vuuren, D. (2015). Evaluating sustainability transitions pathways: Bridging analytical approaches to address governance challenges. *Global Environmental Change*, 35, 239–253.
- Tushman, M. L., and Romanelli, E. (1985). Organizational evolution: Interactions between external and emergent processes and strategic choice. *Research in Organizational Behavior*, 8, 171–222.
- Upham, P., Kivimaa, P., Mickwitz, P., and Åstrand, K. (2014). Climate policy innovation: A sociotechnical transitions perspective. *Environmental Politics*, 23(5), 774–794.
- Veeckman, C., Schuurman, D., Leminen, S., and Westerlund, M. (2013). Linking living lab characteristics and their outcomes: Towards a conceptual framework. *Technology Innovation Management Review*, 3(12), 6–15.
- van de Ven, A. H., Polley, D., Garud, R., and Venkataraman, S. (1999). *The Innovation Journey*. New York: Oxford University Press New York.
- Vreugdenhil, H., Taljaard, S., and Slinger, J. H. (2012). Pilot projects and their diffusion: A case study of integrated coastal management in South Africa. *International Journal of Sustainable Development*, 15(1–2), 148–172.
- Weick, K. E. (1998). Introductory essay: Improvisation as a mindset for organizational analysis. *Organization Science*, 9(5), 543–555.