Research Policy 48 (2019) 1091–1097

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

The tentative governance of emerging science and technology—A conceptual introduction

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ARTICLE INFO

Keywords:
Emerging science and technology
Tentative governance
Experimentation
Technology governance
Policy learning

ABSTRACT

This conceptual introduction to the Special Section examines different modes of 'tentative governance' of Emerging Science and Technology (EST). The notion of tentative governance appears particularly relevant in the case of EST, given all the uncertainties and dynamics related to the scientific base, technologies, possible innovations, societal benefits and potential risks. While one may argue that such uncertainties are not peculiar to EST, it is nevertheless apparent that in industry, society and public policy the level of awareness of these uncertainties has increased, largely as a result of experiences with former emerging technologies (e.g. genetically modified organisms, nuclear technology). Governance is 'tentative' when public and private interventions are designed as a dynamic process that is prudent and preliminary rather than assertive and persistent. Tentative governance typically aims at creating spaces for probing and learning instead of stipulating definitive targets. The paper suggests a heuristic to position and relate the contributions to this Special Section. One main finding emerging from those contributions is that the inherent contingency of EST requires rather tentative approaches to governance, though often in combination with more definitive modes of governance, with the exact mixture involving a balancing act.

1. Tentative governance in emerging science and technology

In this Special Section we explore 'tentative governance' in practice. We bring together studies involving explicit or implicit modes of tentative governance in areas of emerging science and technology (EST), i.e. provisional, flexible, revisable, dynamic and open approaches to governance that include experimentation, learning, reflexivity and reversibility. Many authors agree that the uncertainties of emerging science, technology and innovation require some form of tentative governance approach (e.g. Barben et al., 2008; Bonnin Roca et al., 2017; Boon et al., 2011; Bos and Brown, 2012; Fisher et al., 2006; Hagendijk and Irwin, 2006; Howells, 2006; Lyall and Tait, 2005, Lyall et al., 2009; Macnaghten et al., 2005; Rip, 2010; Rotolo et al., 2015; Sorensen and Williams, 2002; Spinardi and Williams, 2005; Stirling et al., 2006; Wiek et al., 2007). The highly dynamic evolution of many ESTs occurs with new actor constellations and practices related to knowledge production, technological innovation, societal appropriation, the emergence of new markets and changing industrial sectors (e.g. Krafft et al., 2014; Colombelli et al., 2014). At the same time, the change of socio-technical regimes is constrained by path dependencies (David, 1985; Arthur, 1989), most obviously if 'regime transition' is intended, for instance towards 'sustainability' (Markard et al., 2012), or if 'grand societal challenges' need to be addressed (Kuhlmann and Rip, 2018). Evidently, the governance of such structural transformation, triggered by EST or otherwise, is not straightforward (Foray et al., 2012) and can easily fail (Weber and Rohracher, 2012), and it requires some prudent form of experimentation as well. *The uncertainties of EST pose specific challenges to the governance of these fields, which has to cope with ill-defined and often 'moving targets'*. At the same time, tentative action can also be a perfectly reflexive and rational attitude of actors striving for resilience and robustness under conditions of changing circumstances. Then, partial flexibility may be used as a strategy for achieving overall stability.

Acknowledging that governance is, or needs to be, tentative under certain conditions not only has analytic value, but also poses an important challenge for designing governance measures. In addition to the basic concern of developing appropriate governance measures for a particular problem or objective, tentative governance approaches need to consider how a certain degree of flexibility can be maintained, and what would be an appropriate degree of flexibility to ensure sufficient stability at the same time.

One may argue that such uncertainties are not peculiar to current EST, but inherent to science and technological innovation processes at all times. We observe, however, that in industry, society, and public policy the *awareness of these uncertainties seems to have increased*, largely

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https://doi.org/10.1016/j.respol.2019.01.006

Available online 23 January 2019

as a result of problematic experiences with former emerging technologies (e.g. genetically modified organisms, nuclear technology), which confronted the actors involved in the governance of these fields with unexpected risks, societal reactions and societal impacts (cf. van Asselt, 2000; Hooghe and Marks, 2003; Kersbergen et al., 2004; Rothstein et al., 2013; Quack, 2013). As a consequence, policy actors as well as scientists and innovation actors now try to cope with these uncertainties at a very early stage in a deliberate manner.

This is exemplified by governance programmes in nanotechnology or in genomics, which attempt to address public concerns or potential risks at a time when they are only emerging. Examples include: the UK ESRC Genomics Network; the initiatives of the Dutch government-funded Centre for Society and Genomics (CSG); the Dutch government-funded NanoNed and NanoNext Programmes with their explicit focus on Technology Assessment; in the US the National Science Foundation (NSF) Centers for Nanotechnology in Society; the European Commission's 2008 'Code of Conduct for responsible nanosciences and nanotechnologies research'; or the projects for 'Promoting Public Understanding of Science and Technology' by the Japan Science and Technology Agency. Even large-scale initiatives such as the European Future and Emerging Technologies Flagships aim to "[e]ventually" achieve certain goals[1] in a process characterised by "[o]penness and evolution of the" core project "consortia over time"[2]. In all these cases, a decidedly *non-deterministic* approach has been chosen. Governance does not aim at closure early in a process, but rather at setting a framework, nudging in a particular direction, leaving it to the process to determine what can be derived from there. This attitude can be spurred by the recognition of conditions too complex to really be controlled, or when the purpose is to see what options are chosen or emerge.

Committed or obliged to innovate 'responsibly' (Owen et al., 2013; Stilgoe et al., 2013; Kjølberg, 2010; van de Poel et al., 2017; Gurzawska et al., 2017; Yaghmaei, 2016; Scholten et al., 2016), governance actors need to anticipate with regard to perceived uncertainties. This involves cooperation vis-à-vis a multi-polar or polyarchic distribution of power, in which no single actor has the capacity to impose their own preferred solution without considering the views of others (Sabel and Zeitlin, 2010: 9). Since assertive, definitive modes of technology governance (e.g. the introduction of the 'Minitel' videotext system in France – see Kramer, 1993) tends not to provide sufficient space for experimentation, flexibility and learning, novel approaches may be required.

While the analysis of tentative governance appears particularly salient in the field of EST, this does not exclude that such modes of governance may also be apparent in more mature fields of science, technology and innovation, or in governance in general (Jusionyte, 2014; Murphy, 2014; O'Brien, 2000). Tentative modes of governance, be they *regulatory* approaches, *institutional* arrangements or modes of *coordination* among various actor constellations, may in principle be the result of developments within the governance arrangements in many spheres (Jessop, 1997).

To date, particular features of tentative governance have been studied, but in a rather fragmented way. Attention has been paid to features of tentativeness like learning or adaptation and reflexivity, as well as to particular modes of governance such as 'experimental governance'. It is thus timely to undertake a more explicit and overarching analysis of this phenomenon. Most of the contributions to this Special Section take governance efforts in a specific field, place and time period as a starting point, in order to trace the relevance, effects and challenges of tentative modes of governance in the heterogeneous array of forms of governance observed. As a consequence, not only intentional instances of tentative governance come into view, but also more incidental manifestations when governance turns out to be de-facto tentative, along with hybrid arrangements, and sequences of more or less tentative forms of governance. Thus, the balancing between more or less tentative modes of governance turns out to be a key issue in the practice of tentative governance, as shown in a several papers in this Special Section (e.g. Lyall and Tait; Hopkins et al.; Budde and Konrad).

The Special Section aims to offer a *heuristic* and it engages in *exploratory* work. The present conceptual introduction synthesises the individual papers, asking whether these 'tentative' modes of governance constitute a set of phenomena that are sufficiently homogeneous and meaningfully differentiated from other modes of S&T governance to warrant consideration as an analytically useful category. Section 2 of this introduction will introduce 'tentativeness' as a condition and a specific concept of governance. Section 3 will position the concept of tentative governance in the context of other related approaches. In Section 4 conditions and modes of tentative governance are discussed, drawing on the findings in the empirical contributions to this Special Section. Section 5 concludes with a summary and an outlook.

2. 'Tentativeness' as a condition and a concept of governance

While actors in public policy, industry, or civil society organisations attempting to 'govern' EST may try to promote desired effects, often the actor constellations and institutional arrangements, deliberations and decision-making are too complex to achieve the aims directly. Actors cannot be sure whether classical-modernist policy practices or new deliberative ones are likely to prove more effective (cf. Hajer, 2003; Rip, 2010). No easy solutions are in sight. Actors often seem to undertake' explorative', 'underdetermined' or even 'ad hoc' movements in a search for the right constellations and opportunities, strategies and breakthroughs (cf. Nowotny and Testa, 2009: 90–96 & 117–144; Gottweis, 2005a, b). In the following, we briefly outline the notions of 'governance' and tentative governance, as used in this article.

2.1. The concept of governance

Generally, the notion of 'governance' refers, firstly, to the manner or act of governing in a given way or context and, secondly and in particular, to the observation that conventional forms through which state, polity, policy-makers, administration, private companies, and civil society organisations sought to achieve solutions for collective problems are no longer working in the same hierarchical way as (it was claimed) they did in the past. This is not to imply that the hierarchical establishment of political order, or the state operating as the key actor, has become obsolete—but it obviously is not the only way in which the political and administrative world works. Public as much as private organisations have turned, at least partially, to forms of governing that allow for influencing the relationships between more or less independent actors, who tend to assist or affect each other in various ways, through 'coordination' rather than through more or less direct control mechanisms (cf. Benz, 2007:9). 'Governance', in this view, denotes dynamic interrelations of (mostly organised) actors, their resources, interests and power, fora for debate and arenas for negotiation between actors, rules of the game, and policy instruments applied to help achieve legitimate agreements (cf. Kuhlmann, 2007; Kuhlmann et al., 2001; Benz, 2007; Braun, 2006). In regulatory governance theory, governance is defined as "a system of norms and public goods where the co-producers are different kinds of actors" (Bartolini, 2011; Héritier and Rhodes, 2011:8).

The contemporary governance of science, technology and innovation in many countries oscillates between proven and newly developing forms of governance. Governance innovation is taking place or is proposed by various public and private actors. In the European Union, for instance, governance innovation includes the Open Method of Coordination, open consultations and networked agencies (Sabel and Zeitlin, 2010). The MASIS Report of the European Commission (2009)

[1] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/fet-flagships [26 March 2018].

[2] http://ec.europa.eu/information_society/newsroom/cf/dae/document.cfm?action=display&doc_id=7162 [26 March 2018].

on challenging futures in science and society concludes that the key challenge is "to allow for dynamic governance … which requires an open-ended attitude towards governance, a willingness not to press for complete closure" (p. 39). On the one hand, there is much experimentation with practices, institutional arrangements, regulations and instruments—just as the issues of governance as well as their publics and arenas have become highly volatile (Dabrowska, 2010). On the other hand, there is also a move back to more definitive modes of governance. An interesting example is the recent shift of the US FDA from soft forms of regulation for nano-enabled products (e.g. standards and guidelines) to hard regulation. Frequently, industries call for stable legislation, which provides the legal certainty they need for investments (Dorbeck-Jung et al., 2010a, 2010b). Policy actors may also have opposing views as to whether stabilization of governance frameworks is more important or keeping them flexible, as shown in a recent study on Finnish low-carbon policy (Karhunmaa, 2018).

Tentative and definitive forms of governance seem to co-exist and to *co-evolve,* suggesting that achieving an appropriate degree of flexibility is a key issue for tentative governance approaches.

2.2. The concept of tentative governance

We consider governance to be 'tentative' when it is designed, practiced, exercised or evolves as a dynamic process to manage interdependencies and contingencies in *a non-finalizing* way; it is prudent (e.g. involving trial and error, or learning processes in general) and preliminary (e.g. temporally limited) rather than assertive and persistent. Tentative governance actors seek flexibility and act incrementally (Lindblom, 1959; Lindblom and Woodhouse, 1993). The concept of tentative governance aims to capture actors' attempts at creating spaces for probing and learning instead of stipulating options (see also Hoppe, 2010, 2005; Voss et al., 2006; Irwin, 2006). We expect tentative approaches to be favoured where actors try to cope with political and organizational complexities and uncertainties and develop explorative strategies, instead of relying only on orthodox or preservative means. Maintaining flexibility means that an actor either is not (yet) able to act in a more structured and definitive way, or is not willing to do so – in other words, there is an element of either voluntary or unavoidable tentativeness.

To study tentative governance, we suggest a heuristic approach; in social sciences a heuristic is used as an explorative research strategy combining a set of different perspectives (see Fig. 1).

The aim of this simple heuristic is to help reveal 'ideal-typical' processes of establishing or changing social order (see e.g. Abbott, 2004; Psathas, 2005). Ideal-typically, one can contrast more *'tentative modes of governance'* with more *'definitive modes of governance'*, i.e. attempts by key actors (such as governmental agencies) to 'steer' socio-technical developments towards certain desired aims by specified and stable means (for a related overview focusing on network and entrepreneurship theory, see Engel et al., 2017).

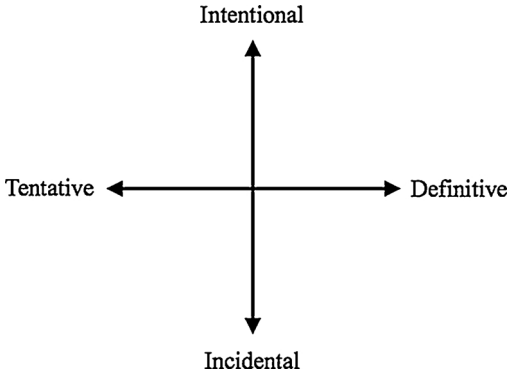

Fig. 1. Basic heuristic for studying governance.

When studying the *de facto* development of governance modes in empirical cases, we might find different degrees of governing that are more or less *intentional* and *incidental*: a definitive governance initiative might finally turn out to develop in a de facto tentative way, for instance if unforeseen adaptations become necessary, and a consciously chosen tentative approach might unfold in a way that encourages key actors to take tough top-down decisions. Thus, an originally rather definitive form of governance can turn into a tentative one or vice versa (Lyall & Tait *in this Special Section*). In this way, one can study the possibilities and limitations of governance efforts, as well as discrepancies between governance as planned and carried out (see the dimensional analysis by Hopkins et al. *in this Special Section*).

The coexistence of, and relation between, intended and incidental forms of governance noted above suggests that tentative governance can be found in hybrid arrangements. In the regulatory governance literature, much attention has been paid to hybrid arrangements of hard and soft regulation (Trubek et al., 2006; Halpern, 2008; Dorbeck-Jung et al., 2010a, 2010b). In the development of technology regulation, combinations of legislation and soft regulation (e.g. technical standards) have played an important role. Being aware of the limits of their technological knowledge, governments have built on private standard-setting and private oversight activities (Kloepfer, 2002). Conversely, industries have often welcomed regulatory collaboration because of the stability, certainty and property protection that public regulation is expected to provide. When tentative modes of governance are introduced in public policy, they tend to be closely related to more definitive and formal governance modes (e.g. legislation). Certain tentative governance forms operate in the 'shadow of hierarchy' (Héritier and Lehmkuhl, 2008; Scharpf, 1997), i.e. with authoritative legal and government power in the background. Discretional legislative power allows for non-legally binding 'soft' regulation including tentative forms (like provisional benchmarks[3]), while also stimulating and encouraging the adoption of private soft regulation, such as the European recommendation for a nanotechnology code of conduct (European Commission, 2008). The coexistence of intended and incidental forms of governance can be productive, dysfunctional, arbitrary or even transformative, leading to a new situation.

In the following section, we discuss various conceptual attempts to understand governance efforts to cope with uncertainty, and explain why it may be useful to conceptualise governance as 'tentative' and to use the suggested research heuristic for studying the different forms, options and limitations of tentative governance.

3. The tentative governance heuristic in conceptual context

We will briefly revisit a number of governance concepts that either highlight specific forms of tentativeness (such as 'reflexive' and 'anticipatory' governance which focus on tentativeness based on a forward-looking logic, while 'adaptation' is more a response to what has happened or is currently happening) or which in a more general sense could claim to be tentative (like experimentation and exploration). We start with concepts that are relatively familiar from their focus on socio-technical regimes and EST, before we consider those used in the broader field of policy studies.

(1) The concept of *'reflexive governance'* seeks to address contingencies and alternatives, and it recognises the possibility of unintended effects of governance 'reflecting' back on the initial situation (Jasanoff, 2004; Jasanoff et al., 2008; Dedeurwaerdere, 2005; Voss et al., 2006; Kemp and Loorbach, 2006; Hendriks and Grin, 2006; Brousseau and Glachant, 2010). 'Reflexive' here means that the

[3] See, for instance, the provisional NanoReferenceValues that have been introduced to control the exposure to nanomaterials at the workplace (Van Broekhuizen and Dorbeck-Jung, 2013).

authors see governance "thrown back on itself and forced to reflect its cognitive and institutional foundations in the idea of modernity" (Voss et al., 2006: xiv). The task of reflexive governance is seen as to shape "societal development which incorporates uncertainty, ignorance, heterogeneity, ambiguity, unintended effects, error and lack of control … qualities … that modern problem-solving procedures try to eliminate" (Voss et al., 2006: xv). Our concept of tentative governance asks whether and in what way governance is reflexive, both in cognitive terms and concerning its working modes, so in this respect it is broader at both ends of the spectrum.

(2) The concept of *'anticipatory governance'*, developed in particular to facilitate nanotechnology funding policies in the US (Barben et al., 2008; Guston, 2014), aims to build the capacities of involved actors with regard to foresight, engagement, and integration. It has been coined as a framework for justifying and rationalising active involvement in the process of co-evolution of technoscience and society. Tentativeness appears here in terms of actively seeking to develop possible future alternatives.

(3) The concept of *'adaptive governance'* has been coined for conditions in which polycentric, nested, quasi-autonomous organisations have to manage situations of rapid change and high uncertainty (cf. Folke et al., 2005; Olsson et al., 2006), situations requiring experimentation and social learning (Leach et al., 2010: 90). In this respect, 'adaptive governance' comes quite close to 'tentativeness'. However, there is a qualitative difference between looking at the capability of a governance system to adapt to rapid change, on the one hand, and 'tentativeness', on the other. Adaptive governance is also much discussed in debates about 'transition management' (Kemp and Loorbach, 2006: 119). The adaptiveness concept already assumes the capability or necessity to adjust and progress to a better state (Robinson et al., 2014; Geels and Schot, 2007), whereas the notion of 'tentativeness' remains neutral with regards to whether it involves adaptation as improvement and learning, or sheer experimentation. Tentative governance serves as a heuristic to investigate whether a particular form of governance is capable of being reflexive and adapting.

(4) In regulatory governance theory, *'experimentalist governance'*, also sometimes known as 'directly deliberative polyarchy (DDP)', is regarded as a recursive process of provisional goal-setting and revision based on learning from the comparison of alternative approaches to advancing in different contexts (Sabel and Zeitlin, 2010). Experimentalist governance typically "results either in revisions of EU directives, regulations, and administrative decisions, or in the elaboration of revisable standards mandated by law and the enunciation of new principles which may eventually be given binding force" (Sabel and Zeitlin, 2008: 276). With regard to the characteristics of dynamics, flexibility, openness, learning and reversibility, experimentalist governance and tentative governance are closely related. One difference between them, however, is their respective starting point; while experimentalist governance starts with from goal-setting, tentative governance begins with the uncertainties (e.g. of EST).

(5) *'Explorative governance'* has been suggested by Bos and Brown (2012). This approach links exploration and experimentation as flexible forms of governance directly with innovation. In practice, a tentative approach could also be one that uses just conventional means of governing; there is no evident mechanism that automatically associates tentativeness with innovation in governance.

(6) *Distributive governance*, as framed by Abbott (2000; cf. also Geiselhart, 2001), is meant as a model of multilateral governance that has evolved "between the WTO and World Intellectual Property Organization (WIPO) since the conclusion of the GATT Uruguay Round" (Abbott, 2000 :65) "in connection with genetically modified organisms" (p. 64) as a reaction to the demands for new policies, rules, and greater participation in decision-making processes: "This model involves the distribution of governance responsibilities to the institution best adapted to the particular subject-matter or goal-attainment, but within an integrated decision-making and enforcement structure" (p. 65). Tentative governance will certainly include distributed modes of governance.

(7) The concept of *'mixed governance'* (Weyer, 2006) reminds us of the frequent combination of central coordination and steering with decentralised self-coordination. Weyer (2006: 127) illustrates this with the case of aviation technology where a system ran out of control while experimenting with new modes of governance and technology combining central control and decentralised self-organisation. This case provides an example of a mix of partially intended and partially unintended loss of control, thus being tentative in the nature of its governance.

This overview of governance concepts may not be complete but it indicates that there exists a broad spectrum of emerging concepts aiming to address the challenge of coping with uncertainties, associated with more or less specific contexts, with more or less normative ambitions.

With the tentative governance perspective, we see all such approaches as efforts to address broadly the same challenge: of keeping up with a moving target shaped by technoscientific, economic, and political-cultural developments. Our concept is neutral in normative terms; it is open to various temporal, spatial, and social circumstances, and it is not bound to one specific context of use (even though we discuss it here in the context of EST).

There are also *governance practice-oriented* approaches relevant to tentative governance, i.e. attempts at shaping new technologies or transforming socio-technical regimes. The governance approaches discussed so far have a relatively strong conceptual focus, whereas practice-oriented approaches imply applicable and, in many cases, applied forms of implementing governance of EST (e.g. 'boundary work' or 'convergence work' with political, policy or scientific bodies, as well as anticipatory studies and scenario workshops as modus operandi – see e.g. Gieryn, 1995; Jasanoff, 2011; Stegmaier, 2009). Such approaches can be supported by various governance 'tools', such as 'constructive' or 'real-time' technology assessment (henceforth abbreviated to CTA and TA; see e.g. Rip, 2011; Rip and Kulve, 2008; Kuhlmann, 2012; Rip et al., 1995), 'ethical, legal and societal issues (ELSI) studies' (Forsberg, 2014; Myskja et al., 2014; Rip, 2009; Zwart and Nelis, 2009; Fisher et al., 2006; Avard et al., 2006; Yesley, 2008), or 'transition management' (Markard et al., 2012; Kern and Smith, 2008; Kemp and Loorbach, 2006; Smith and Kern, 2009). 'Responsible Research and Innovation' (RRI) constitutes a recent approach with at least implicit governance ambitions, certainly in the context of the European Union (Owen et al., 2013; Rip, 2014). RRI comprises forms of activities embodying research and governance service styles developed in previous TA, ELSI and ethics schemes. These governance-practice-oriented approaches may be applicable to more comprehensive governance frameworks.

Last but not least, the debate about the need for, and recent framing of, 'transformative innovation policy' should also be mentioned here (Schot and Steinmueller, 2018; Kuhlmann and Rip, 2018), where the aim is to bring about socio-technical system change, with 'experimentation' (with EST and beyond) as a key governance characteristic.

4. Findings from the contributions to this Special Section

4.1. Overview of the contributions to the Special Section

The contributions to this Special Section all examine how the governance approaches to a particular field of emerging technology and in a specific geographical area have evolved or been implemented over a certain period. The first two papers comprise longitudinal studies focusing on how governance measures changed over time, exhibiting different degrees of more or less tentative forms of governance and the interplay of tentative and definitive elements in the governance. The

last two papers zoom in on specific examples of tentative governance initiatives – processes of stakeholder engagement in the UK, and socio-technical integration as a feature of the US National Nanotechnology Initiative. The papers not only address the aim of understanding conceptually and empirically the phenomenon of tentative governance, but also contribute to a number of research themes and conceptual developments in innovation studies more broadly, such as the functions and dynamics of innovation systems, the multi-level perspective, the role of expectations, public engagement, and the financing of innovation.

Budde and Konrad in their study of German fuel cell policy investigate a key element of the dynamics and governance of EST characterized by multiple uncertainties—namely, expectations regarding the development and potential of particular technologies. They focus on how and why expectations changed, and how policy dealt with these dynamics, either by taking past and possible future changes reflexively into account in the set-up of governance measures, or after the fact when expectations had changed. Thus, the paper shows different forms of *intentional* and more *incidental, de-facto* tentativeness in governance and how these interrelate. The paper also elaborates on the conditions under which policy becomes responsive to niche expectations and contributes to our understanding of the dynamics of expectations as resulting not only from the processes within a technological field, but also from the dynamics of interrelated expectations. Policy measures in this case can be characterized as balancing tentative and definitive forms of governance: governance measures were committed for a rather long timeframe of ten years, but at the same time a certain degree of flexibility was anticipated to reflexively take into account past and potential future dynamics of expectations. Furthermore, the governance measures were de-facto adapted to the actual expectation dynamics, in particular to the rise in expectations with regard to electric-battery vehicles. Thus, this case shows that reflexively dealing with dynamics and uncertainty may also include dedicated and successful efforts to stabilize policy support and create some resilience, in this case to avoid policy support simply following expectation dynamics. Thus, this form of tentative governance can be described as dynamically stable.

Hopkins, Crane, Nightingale and Baden-Fuller study how policy-makers have blended tentative and definitive elements in the design and implementation of six different kinds of UK policies targeting, or relevant for, therapeutic biotech. Firstly, they develop a framework for characterizing tentative and definitive forms of policy instruments that considers which functions of an innovation system are targeted and evaluates the degree of tentativeness along different governance dimensions. Secondly, Hopkins et al. use this framework for a longitudinal analysis of funding instruments from the 1980s onwards. In line with Budde & Konrad, they find that tentative and definitive governance are used together to balance the need for certainty with the necessary responsiveness to the dynamic circumstances that surround technological emergence. Moreover, they find that the relative use of each is shaped as much by broader landscape influences as by technology or sectoral factors. Over time, both the opening up of policy instruments is observed as well as the routinization of initially experimental approaches. It is apparent that tentativeness is sometimes sought as a means to enable learning and experimenting, but can also be an option when more definitive forms are hard to enforce. In addition, various challenges are identified, such as how to maintain synergistic rather than either/or relationships between state and non-state actors when each tends to leave the market at different times, and the potential danger of incumbent influences.

Staying in the context of life science, but moving to a more normative discussion of what constitutes appropriate forms of more or less tentative governance, *Lyall and Tait* critically reflect on their long-term experience with engagement and regulatory initiatives related to the governance of life science in the UK, drawing a number of lessons from this. They use the heuristic of tentative governance to reflect on the appropriateness of different forms of public engagement as a field moves from upstream to downstream stages, and derive a set of guidelines for constructive stakeholder engagement. They also shed light on how a tentative approach may be connected to a more adaptive one, further illustrating the issue of balancing flexibility and stability. A tentative and very open form of governance including public engagement is suggested as appropriate in earlier upstream stages, when uncertainties are particularly great, while further downstream an EST governance may tend to become rather more adaptive, giving greater attention to the interaction with top-down and already existing policies and rules.

Fisher studies the emergence of one of the key policy support initiatives in EST, the US National Nanotechnology Initiative (NNI). The aim is to understand how the unprecedented mandate for socio-technical integration – that is, integrating societal, ethical and environmental research with technical research and development – became part of the programme. He argues that the mandate arose from policy-makers' awareness of two dynamic sources of uncertainty, namely 'moving targets' in the form of fluidity of public concerns, and the contingency and malleability of research and technological directions. Fisher traces the agenda-setting process and the discursive and conceptual foundations for this innovative governance mechanism through document analysis and interviews with policy elites. He shows that the mandate was conceived and partially formulated in a self-consciously experimental manner, reflecting its unprecedented nature as an approach in US science and technology policy and the recognized uncertainties related to the societal contexts of science and innovation, thus making it a good example of tentative governance.

A key finding from these contributions and the cases they discuss is that the contingency of EST governance in particular and innovation policy in general should not be underestimated. Tentative forms of governance are an empirically relevant phenomenon, visible in diverging fields such as life sciences, energy and transport, or nanotechnology. This becomes particularly apparent for intentional modes, reflecting the striving for dynamic and flexible forms of governance, or offering an approach when more definitive forms are difficult to achieve or when adaptation becomes necessary due to changing circumstances.

In addition, the papers in this Special Section suggest a number of approaches for studying tentative modes of governing EST, as well as linking the concept to established lines of research in the governance of science, technology and innovation. However, tentative governance may not operate in isolation or as a one-way street. In several accounts by our contributors we found mixed forms of governance, in which tentativeness plays a key role but is temporally or structurally linked to another governance mode: Hopkins et al. (*in this Special Section*) show for their six cases various combinations of tentative with definitive governance; Lyall & Tait (*in this Special Section*) argue for the development from more tentative governance downstream to more adaptive governance upstream; and Fisher (*in this Special Section*) suggests persisting ambivalence, which can lead to a stabilised quest for openness or a 'definitive tentativeness'. What is more, in many situations the balancing of tentative and definitive forms turns out to be a recurring theme, with dynamic stability and resilience being an important concern in addition to the goal of allowing for openness and flexibility. A further recurring theme in the papers is that developments in the wider policy context are just as important an influence as those within a particular technology field or sector.

5. Conclusion and outlook

The papers in this Special Section together enhance our understanding of the different forms which tentative governance may take. Many of the papers show that tentative governance often involves a balancing act between creating flexibility and maintaining stability, between opening and closing options, and between more or less tentative forms, rather than creating as much flexibility as possible. Thus, tentative governance in practice is a *matter of degree* rather than a fully

discrete phenomenon.

The concept of tentative governance, as introduced here, does not represent a specific new form of governance. As a heuristic, however, it helps to make clear how much tentative elements are included in the governing of EST, and to identify the particular challenges and possible coping strategies related to this type of governance. This collection of papers together with our conceptual analysis offers a first attempt to systematise such efforts, opening up the possibility for the future elaboration of a more fine-grained tentative governance concept.

The added value generated by the tentative governance concept resides, first and foremost, in making clear that in the context of innovation studies governance needs to be appropriately conceptualised in order to avoid unrealistic assumptions about the steering of innovation in a desired way or direction. Rather, the concept of governance should help to open-up insights about circumstances, conditions, contexts, and about the limits, boundedness, and sometimes failures of overly deterministic framings and rationalisations. Moreover, as a heuristic, the concept of tentative governance introduces and encourages explanations of innovation that are of a more specific, situated character than more positivist approaches would suggest.

Acknowledging that governance is or needs to be tentative under certain conditions not only has a certain analytic value, but also reveals an important challenge for designing governance measures. In addition to the basic concern of developing appropriate governance measures for a particular problem or aim, tentative governance approaches need to consider how an appropriate degree of flexibility can be ensured, while at the same time maintaining sufficient stability.

Acknowledgements

This paper and the Special Section have benefited from valuable conceptual contributions by Bärbel Dorbeck-Jung. Thanks also go to Martin Bell, Martin Kenney and Ben Martin. All the usual disclaimers apply.

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