Introduction: Science and public policy – relations in flux

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This *Handbook on Science and Public Policy* will capture a landscape in flux: the relation between science and society has been changing in the last decades, and it has become a hot topic in the science system and in science policy studies. Even though historically the topic is not new, it seems that the roles of science and innovation are being debated more explicitly: the demand for science-based innovation is growing while the legitimation of scientific research is being questioned. Scientific knowledge is hailed as a significant societal and economic resource in global competition. Innovations emerging from science are considered to be the key to market success and prosperity. At the same time, scientific knowledge and research-based innovation are supposed to address so-called grand societal challenges and help achieve 'sustainable development goals' (United Nations 2015). Yet, there is also pressure to legitimise the increasing amounts of public funding for research worldwide. And the questions 'how does society benefit from science?' and 'which research is "relevant" and "useful"?' are raised emphatically.

The changing relationship between science and society significantly challenges science policy: research is expected to foster and support innovation not only via new technologies but also in a way which is socially acceptable and sustainable. Moreover, it is expected to develop new instruments, methods and practices for its own accountability and legitimation that are accepted by the scientific community. This is where this *Handbook* comes in. It focuses on how science policy has changed over the last decades and raises several overarching questions: What are the consequences of changing science policies for science and the science systems nationally and internationally? How far do they go? Do they tackle the fundamental principles of science, its norms, standards and reputation systems? And what does this mean for modern science (and technology)? The chapters of the *Handbook* provide different answers from a broad range of theoretical and conceptual perspectives.

As a guideline we assume an interlinked model between science and science policy, in which science policy influences the structures and

orientations of science and knowledge production and vice versa. Both are influenced by overarching principles and guiding visions, often triggered through the Organisation for Economic Co-operation and Development (OECD) (Henriques and Larédo 2013). Science and public policy go hand in hand. Their pairing comes with tensions, yet the two need each other. Since the Enlightenment, the rise of modern sciences and their institutionalisation have been closely interwoven with the development of modern states and their governments, public policies and related forms of governance (Fischer 2003). While both domains of institutionalised agency continue to emphasise their relative independence, they have in fact been *co-constituting* each other, up until today. Both domains claim to structure and enhance the basic conditions of modern societies, directly or indirectly, through knowledge, regulation and investment. Both tend to refer to shared overarching narratives or 'frames' (Goffman 1974; Rein and Schön 1996; Godin 2009), from the promises of 'science: the endless frontier' (Bush 1945), through 'technological competitiveness' (e.g. Chesnais 1986) for welfare creation, to the 'knowledge economy' (e.g. Powell and Snellman 2004) and more recently to 'transformative innovation policy' for sustainable and inclusive development (e.g. Schot and Steinmueller 2018).

In the last decades, these frames have been addressed and reflected, implicitly or explicitly, in a number of outstanding handbook-like publications: Sheila Jasanoff's collection of seminal analyses of science and politics summarises the state of knowledge at the end of the twentieth century (*Comparative Science and Technology Policy*, Jasanoff 1997). Building on Stuart Blume's observation that 'the social institution of modern science is essentially political and that, moreover, the scientific role is an integral part of the political system of the modern state' (Blume 1974, 1), the authors of *The New Political Sociology of Science* (Frickel and Moore 2006) carried out a broad analysis of the institutions, networks and power relations in advanced economies, in particular in the United States. In a similar approach, Guston and Sarewitz (2006) gathered together a research programme in their book on the factors shaping science and technology policy, including scientists themselves, who act as 'honest brokers' (Pielke 2007). In the early 2000s, the role of science for public policy received the increased attention of scholars in the United States 'in response to policymakers' increased demands for better tools and the social sciences' capacity to provide them' (Fealing et al. 2011). Triggered by the US National Science Foundation's Science of Science and Innovation Policy (SciSIP) programme, supporting research into the scientific basis of science and innovation policy, the handbook *The Science of Science Policy* (Fealing et al. 2011) aimed at exploring the foundations of an evidence-based platform for the field.

Yet, most of the above scholarly writings are affected by a certain US bias, that is, reflecting the country's particular setting for science and public policy: a strong science base; robust public *and* private funding of science and technology; and a recurrent ideological claim that science is or should be independent of political steering. Our *Handbook on Science and Public Policy* draws on the above-mentioned literature while taking a transnational perspective. Against the backdrop of the institutional changes affecting science systems, this handbook *firstly* aims at providing an overview of recent developments from a national and transnational/global perspective. *Secondly*, it aims to gather information about the classical instruments of scientific policy steering and coordination as well as about the actors and institutions (undergoing transformation). It incorporates a multidisciplinary perspective (political sciences, sociology, history, economy) on the driving forces, the framework of conditions and instruments at hand for science policy and combines theoretical/conceptual approaches along with empirical and comparative contributions.

We know from science and innovation studies that the relationship between science and society has consequences also for science policy (Martin 2012). Since its very inception, it has led to the question, so to speak, of science's usefulness to society (Kaldewey 2013). Recent science studies widely agree that science has been transformed not merely due to utilitarian considerations but also due to changing environmental conditions. Diagnoses vary about how and to what degree change has occurred: a stronger influence from non-scientific actors has purportedly been established (Gibbons et al. 1994; Nowotny et al. 2001), which is said to have led to a new type of inter- and transdisciplinary (socially robust) knowledge, with academic discipline-oriented science experiencing some push back and slightly decreasing importance. Over the last years, this debate has been carried out under the keyword 'citizen science', which refers to a situation where citizens are given an ever more active role in the production and even evaluation of scientific knowledge (see Franzen, Chapter 17 in this handbook). A closer linkage between science and other social areas has also been established (Weingart 2001), involving everything from state policy to the economy, the legal system, the public realm and mass media, such that one may speak of a simultaneous socialisation of science and a scientification of society. Furthermore, these modified and more permeable science–society boundaries are reflected in the diagnosis of the 'blurring of boundaries' as well as in the creation of a 'postnormal science' (Funtowicz and Ravetz 1993). Moreover, the danger of 'academic capitalism' is being invoked by some (Slaughter and Rhoades 2004). They assume that capitalist market mechanisms are increasingly being introduced within the science system because application- and value-oriented science

is presumed to have become the dominant form of knowledge production. On the other hand, the advantages of the Triple Helix structure – increased co-production of knowledge in a triad between academic institutions, industry and state institutions – have also been proclaimed (Etzkowitz 1998). The different interpretations of the boundaries between social areas and science, of the crossings and hybridisations of those boundaries, and of emerging new demarcations entail greatly differing consequences. The ongoing changes can be perceived as jeopardising the scientific profession (Schimank 2005) or as a viable option: 'the social and institutional opportunities where society may enter into a dialogue need fostering' (Nowotny 2000, 222).

A country's science policy is seen as a promising lever for its economic ability to compete as well as for its social stability. Furthermore, globally there is a new obligation for scholarship to be transparent for and accountable to society. When, above all, legitimising public funding and the corresponding accounting is under the spotlight, processes such as *open access* are meant to render the production of scientific knowledge and the institutional conditions thereof crystal clear for anyone. This, in turn, rebalances the relationship between science and the public. At the same time, however, an ever more widely shared verdict claims that the societal and economic output of scholarship is unsatisfactory: too few innovations find their way into the market and generate economic benefits. According to this view, the links in the value creation chain from scientific hypothesis to successful product are simply not forged with enough regularity.

Called to action by the 'grand societal challenges', science policy is now attempting to find new ways forward on the national, European and global levels. These demand a systematic perspective and require modified governance for the management of a comprehensive transformation process in which technical and societal issues are equally put on the agenda. Even the wording of the European Framework Programmes ('Horizon 2020') that called for 'science with and for society' signals a stronger reference to society, which refers back, in part, to the offers of interpretation from science studies. Also, the concept of 'responsible research and innovation' mainly aims to harmonise the orientation and results of research and innovation with societal needs and values within the European research landscape, a reasoning very much inspired by the social studies of science (e.g. Stilgoe et al. 2013; Kuhlmann et al. 2016; Owen and Pansera, Chapter 2 in this *Handbook*). To this end, conceptual approaches to meta-governance of science and innovation have been suggested (Kuhlmann and Rip, Chapter 1 in this *Handbook*).

In our understanding, science policy comprises not only the institutionalisation and funding of universities and research organisations but

also the governance and regulations in the wider fields of innovation and knowledge creation in general. Financing and governance structures are the central pillars of science policy. In addition, factors like reputation, career patterns and the role of scientists in society, the participation of citizens and the relationship between science, the economy and civil society are highly relevant in and for science policy. Science policy occurs on various levels: as inner-institutional micro-policy applied when actionable resources are superposed or devalued; as institutional policy that has to apply new structures and fulfil new management and coordination performance requirements; as a new political arrangement, because new coordination mechanisms arise between ministries, funding institutions, the public, scientific-political institutions, universities, research institutions and private enterprises; and finally as classical domain policy, which has to find an adapted functional description for itself in the face of international regulations and new tasks. Across these levels, the book chapters will address science as a policy-triggered project and public policy as a science-driven effort.

This *Handbook on Science and Public Policy* assembles the state of insights into the co-evolutionary and precarious relations between science and public policy. Beyond, the book offers an outlook on emerging challenges for science (together with technology and innovation) in changing societies, and related policy requirements, as well as challenges for public policy in view of science-driven economic, societal and cultural changes. In short, this book deals with science as a policy-triggered project as well as public policy as a science-driven venture, both coping with change. Change in several respects is the focus of the handbook and its six sections:

- *Changing contract between science, society, and public policy*: Participatory science, citizen science, public engagement: is a new social contract for science in sight? The authors of this section discuss this question from different angles. Approaches like the ones mentioned above do not only pay attention to normative aspects; they also affect the epistemic core of science. Research and innovation increasingly appear as collaborative processes in which a whole – and, at times, new – range of actors and stakeholder groups contribute to responsible science in society.

  The section also looks at science and public policy as co-evolving processes that lead to the rise of a 'next generation' of science policy which also impacts the modes of governance. Among others, authors focus on the rise of the concept of 'Responsible Research and Innovation' and discuss its translation into policy and practice. Further attention is dedicated to the notion and policy concept of

the so-called grand societal challenges, as well as to the role of public engagement for the emerging future constitution of knowledge societies. (Kuhlmann and Rip; Owen and Pansera; Maasen and Dickel; Voß – Chapters 1–4 in this *Handbook*.)

- *Changing national/global science and policy landscape*: Internationalisation results in transnational research networks that reach beyond the scientific policy set forth by any one state. This raises questions as to where the borders lie when it comes to steering policies, coordination and regulation of scholarship by the *nation state*. If we accept that global networks of scientific collaboration are emergent systems that are here to stay, we need to develop organisational concepts around it. One approach is a nested heterarchy, challenging governments. Furthermore, interest in science diplomacy is rising across the globe – and this despite the fact that there exists no common denominator of science diplomacy or uniformly accepted definition.

  This section also analyses diverse national and international approaches to science systems and science and innovation policies. While the characteristics of science and technology policies in the United States underscore the importance of cross-country collaboration to solve increasingly complex policy problems, the innovation, science and research landscape in Australia is distinctively international and presently appears as not making the best use of its available resources. France, on the other hand, is an example of a more nationally driven science policy. (Wagner; Flink and Rüffin; Aust and Gozlan; Corley; Hussey, McEwan and Playford – Chapters 5–9 in this *Handbook*.)
- *Changing actors and framings of science and public policy*: New actors, such as civil society and philanthropic organisations, industry, grass-roots and garage innovation movements, aim to drive science and innovation to address societal demands and major 'societal challenges'. Complex problems are forcing actors to search for alternative modes of interaction, and the formats of cooperation between science, science policy and other societal actors to create new knowledge for solving these problems are also changing. The fragmentation and recombination of authority leads to a diversified landscape of expertise. Looking at gender policies we learn that the complexity of actors, the importance of institutional entrepreneurs, networks and advocacy groups have led to a non-linear policy learning.

  This section also illustrates the limitations of science policy. In many countries, changes to the funding and governance structures of scientific research are altering the distribution of authority over

the choices and formulation of research problems and intellectual approaches for tackling them. The German universities reform project 'Excellence Initiative', for instance, shows that the idea of allowing more sectoral permeability and promoting more flexibility and an expanded culture of recognition in order to strengthen innovative capacity is only slowly gaining ground. Looking back at the 1960s and 1970s, we understand how research, once taken for granted as a key element of innovation and a source of socio-economic progress, may become marginalised. In recent years new forms of knowledge production and a diversified landscape of expertise have emerged. (Godin; Whitley; Huisman and Seeber; Strassheim and Canzler; Knie and Simon; Leišytė – Chapters 10–15 in this *Handbook*.)

- *Changing production of knowledge*: Forms of knowledge production are becoming ever more differentiated. Alongside classical basic or application-oriented research we are witnessing an explosion of inter- and transdisciplinary research (*co-evolution* or *co-production* of science), research which is often organised in temporary networks and brings together dissimilar actors from the sciences and the economy as well as civil society (the last being referred to as *participatory science*). The borderland between science and society is being rearranged, with modes of scientific knowledge diffusing into society and science reconsidering itself as part of society. The push for interdisciplinary research has been one of the most prominent in recent science policy. Citizen participation in the research process is seen as an opportunity to generate socially robust knowledge and as a method of bridging the gap between science and society. Another example of changing models of knowledge production are university–industry–government interactions, well known as the Triple Helix model. Furthermore, the idea of open science (open access, open data, open metrics, open review) is becoming a reality, thanks to the all-permeating digital revolution and its effects. In sum, science policy is getting more diverse, more complex, and ever more far reaching in its impact on science. (Böschen; Franzen; Etzkowitz and Zhou; Stamm – Chapters 16–19 in this *Handbook*.)
- *Changing governance of scientific research and related public policies*: Science governance reforms over the last few decades have put so-called New Public Management (NPM) into place. A number of myths have developed around this (see Mazzucato 2015), but NPM has at least partly replaced traditional forms of steering, coordination and evaluation of scholarship with output-oriented forms of governance. It addresses, above all, academies and universities as the main producers of scientific knowledge and is aimed at bringing

about improved performance. Competition, monitoring and expectations of application are important points for alignment. In the process, terms of performance, evaluation criteria and orientation models are brought in from other societal spheres and imposed on scholars, academic and scientific organisations, and on scholarship itself (Simon and Knie 2013). Furthermore, for improving the commercialisation of research results different forms of science and industry cooperation are fostered.

However, looking at the governance of science, it must be stressed that science policy differs significantly from other policy areas: the knowledge producers in the form of scientific communities require far-reaching autonomy in the steering and coordination of science as an essential precondition for creative scientific action. Due to this, classical science policy is caught in the dilemma of defending scholarly autonomy while making sure that societal needs and demands are adequately taken into account during the knowledge production process. The competing paradigms are reflected in the science policy discourses on 'excellence' and 'relevance' or impact. Both can be interpreted as boundary objects at the interface between the world of research and the world of policy.

Generally, we can observe recent trends in public policy towards prioritising research that produces direct benefits to society. In this section authors investigate the mechanisms and effects through which research content can be intentionally influenced. They also enquire into which means of changing research content are available to which actors and analyse how ongoing processes of differentiation and repositioning of research funding organisations are linked to transformations in science policy and more general in public policy. Finally, this section looks at the effects of coordination and membership on changes in European governance. (Borrás; Gläser; Lepori and Reale; Wouters; Donovan – Chapters 20–24 in this *Handbook*.)

- *Changing studies of science policy, science, and innovation*: Different conceptual and methodological approaches with different orientations to external academic and non-academic audiences exist with regard to the field of science and public policy: 'Innovation Studies', 'Science and Technology Studies' and the field of 'Science Policy Studies'. In general they are well established and institutionally separated, with each having their 'own' audience. However, they are currently being confronted with new challenges. How do they react? What are the options and opportunities? How can the intellectual and institutional divisions be overcome? (Williams; Martin – Chapters 25–26 in this *Handbook*.)

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