D5.1 Scoping Report: Open Science Outputs in Policy-Making and Public Participation

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Observing and Negating Matthew Effects in Responsible Research and Innovation Transition

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This deliverable summarizes the evidence to date on how scholarly resources are used in selected areas of policy-making with a special emphasis on Open Science practices and outputs. It introduces and specifies the methods for upcoming research tasks 5.2 and 5.3.

Document Description

D5.1 – Scoping Report: Open Science Outputs in Policy Making and Public Participation

D5.1 Scoping Report: Open Science Outputs in Policy Making and Public Participation			
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Abbreviations

CC   Creative Commons

EBM   Evidence-based Medicine

EBP   Evidence-based Policy

EPTA   European Parliamentary Technology Assessment Network

EU   European Union

FAIR   findable, Accessible, Interoperable, Reusable

GMO   Genetically Modified Organisms

KT   Knowledge Transfer

KTE   Knowledge Transfer & Exchange

NOTA   Netherlands Office of Technology Assessment

OS   Open Science

POST   Parliamentary Office of Science and Technology

PUS   Public Understanding of Science

RRI   Responsible Research and Innovation

STS   Science and Technology Studies

TA   Technology Assessment

TR   Transdisciplinary Research

Executive Summary

The use of publicly available scientific outputs by policymakers has been claimed to be one of the benefits of Open Science (OS). However, there is yet little empirical evidence as to the impact of OS practices on research uptake by policymakers. In fact, the relationship between evidence and policy is frequently described as a "gap", highlighting the difficulties that prohibit the use of scientific evidence in policy making. How can OS impact on policies, then, if policy makers do not make sufficient use of scientific outputs as it is? The deliverable addresses this question by systematically summarizing the evidence to date on how policy makers use scholarly resources with a special focus on open research practices, thereby laying the groundwork for research activities in tasks 5.2 and 5.3 of the Horizon2020 project "ON-MERRIT"[1] by answering the following key questions:

RQ1   How are Open Science outputs used in policy making?
RQ2   Which societal actors participate in Responsible Research & Innovation (RRI) and OS policy making?

These objectives can be regarded as generalized versions of the following questions:
- What are the mechanisms of knowledge transfer identified in the literature?
- Which factors influence policy outcomes?
- Why do policymakers use academic literature/research evidence?
- Which contextual factors impact the use of evidence by policymakers?
- How does access to scientific results impact on the use of evidence by policymakers?

The report is structured as follows: Section 1 motivates and describes the research questions and defines the methodology. Section 2 presents the results of a systematic literature review on research uptake in selected policy areas. We found that researchers and policymakers are described as living in different and frequently incompatible worlds. Policymakers seek information that is timely, relevant, credible, and readily available. They struggle with knowledge management and appraisal of research outputs, in addition to a lack of resources, knowledge, and skills to utilize research. Research awareness is low, and few academics participate directly in the policy process. Factors conducive to research uptake are access to relevant and clear information and good relationships between researchers and policymakers, as policymakers prefer receiving information through personal networks rather than academic publications. The reviewed literature suggests that the availability of information in the form of academic publications and other research outputs is of secondary concern. Research on the use of evidence in policymaking is frequently criticised for falling short on current theories of policy processes. These processes need to be better understood before assessing the impact of OS. Section 3 suggests understanding both RRI and OS as continuing earlier attempts to negotiate the role of science in society. The public as instrumental to the scientific method has a long history, starting with the Hobbes-Boyle-controversy in the 1660s all the way to the peer review system and the contemporary OS movement. The science-society relationship amounts to a complex interplay of competing forces and trade-offs between the autonomy of science and its capacity to serve societal needs. Through

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[1] https://on-merrit.eu/.

demonstrating their contribution to economic prosperity, scientists were very successful in forging strategic alliances, especially with industry. Developments such as genetics and nuclear technology led to increasing public attention and critique. As a response to growing resistance, scientists sought to enhance public support and thereby secure public funding. Building upon earlier experiences, RRI attempts a reconfiguration of the science-society relationship by bringing together societal relevance, claims to autonomy, public policy, and OS practices in novel ways, drawing on elaborated methods and conceptual frameworks from the long history of negotiating the science-society relationship. Section 4 summarizes the findings to suggest that improved infrastructure for sharing scientific outputs could have a positive impact on the use of evidence in policy making and introduces a set of methods to be used in research tasks 5.2 and 5.3 associated with this work package. Following section 5 (References), section 6 (Annex) details the search strings used for the systematic literature review as well as including a (tentative) exposition of research instruments (survey and interviews). The research leading to the results presented within these pages has received funding from the European Union's Research and Innovation Programme under Grant Agreement no. 824612.

1 Introduction

1.1 Background

The use of publicly available scientific results and data by policymakers and other non-academic stakeholders has been claimed to be one of the benefits of Open Science (e.g. Olesk, Kaal, and Toom 2019; Tennant, Jacques, and Collister 2016). In the "age of expertise" (Fisher 2009, cited after Krick 2019), governance relies increasingly on expert knowledge (Hilgartner 2000; Weingart 2001). Simultaneously, there is an increasing demand for public participation in policy making to strengthen the legitimacy of the policy process (Krick 2019). As a response to these demands, policymakers have started to set up participatory programmes. Additionally, many countries have created advisory bodies (or similar institutions) to facilitate knowledge transfer (KT). However, the normative demands for knowledge-driven and participatory governance are in tension (epistemic-democratic divide) (Krick 2019). In the 1990s, Gibbons and Colleagues (Gibbons et al. 1994; Nowotny, Scott, and Gibbons 2003) dubbed the new focus on demand-driven research "mode-2 science". Some say that mode-2 science "represents a revised social contract between society and science" (Kothari et al. 2011), while others point out that Mode 2 science is "the original format of science before its academic institutionalization in the 19th century" (Etzkowitz and Leydesdorff 2000). According to e.g. Nowotny et al. (2003), Mode 1 emerged in the late 19th century as an ideal to protect academia's organizational structures from economic interests.

These developments constitute a significant departure from the ethos of science as described by Merton (1973). Disinterestedness has given way to an entrepreneurial paradigm (Münch 2014) requiring universities to acquire capital and produce knowledge (Nowotny, Scott, and Gibbons 2003). Despite the fundamental indeterminacy of scientific knowledge (as attested to both by philosophy of science and by sociology of science), science has maintained, and continues to exert, a considerable degree of cultural authority (Drori 2003) as a "producer of truths about our natural world" (Jasanoff 1997, xv).

Discussions concerning the accountability of science and scientists towards society and the general public are not new, even though the terminology has changed over the years. Following the experience of World War II and the potentially devastating effects of science and technology (Weingart 2001), post-war theories of the science-society relationship assumed a causal relationship between scientific and socioeconomic advancement. More critical readings followed. From the 1980s onwards, the science-society relationship has been framed as an issue of public understanding of science (PUS), though various research agendas and political ideologies have been associated with the term (large-scale quantitative surveys, cognitive psychology and mental models, and qualitative field studies) (Wynne 1995). For Weingart (1983; 2001) scientization of policy has become a structural element of modern societies[2], leading some to claim that scientization equals rationalization (Drori 2003). For Weingart (1983), scientization is one aspect of rationalization. Science provides a mythology of universality and manageability (Drori 2008) while at the same time being increasingly politicized.

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[2] Recall here also the works of Ulrich Beck on the risk society (U. Beck 1986) and reflexive modernisation (U. Beck, Giddens, and Lash 1996).

1.2 Research Aims: Scientific Outputs in Policy Making

The epistemic-democratic tension raises serious problems for the policy-expertise-relationship. Expert knowledge has originally been framed as a threat to democracy (Krick 2019; Weingart 2001), as the principles underlying democracy (e.g. inclusion, equality) seem to be patently incompatible with epistemic needs (ordinary citizens' abilities with respect to taking a stand in complex issues). Among other things, the tension has raised the issue of the legitimacy of experts (Weingart 2001). However, this issue seems to have vanished with the democratisation of expert knowledge (e.g., through increased transparency and access to knowledge).

A second problem arises with the role of scientific expertise as a provider of legitimacy (Drori 2003). Scientization paradoxically has not led to political deliberation becoming more rational. If anything, discussions have become more controversial. These two worries notwithstanding, policymakers rely on scientific evidence to a large degree as a provider of certainty (Cairney, Oliver, and Wellstead 2016). Still, the relationship between evidence and policy is frequently described as a "gap" (Boecher 2016; Brownson and Jones 2009; Cairney, Oliver, and Wellstead 2016; Choi et al. 2016; Ellen, Lavis, et al. 2014; Ellen, Léon, et al. 2014), highlighting the difficulties that stand in the way of using scientific evidence in policy making. Here, a "new social contract" between researchers and other stakeholders (Kothari et al. 2011) is invoked: Collaboration and communication between researchers and policymakers are expected to "bridge the gap" (Brownson and Jones 2009; Dodson, Geary, and Brownson 2015; Haines, Kuruvilla, and Borchert 2004).

There is yet little empirical evidence as to the effectiveness of OS with regards to either boosting the uptake of scientific results by policymakers or the public's ability to influence policy making. It has been suggested for quite some time now that scientific knowledge is pivotal in policy making (Nutley and Webb 2009). The emergence of the OS movement at the beginning of the 21st century promises to further change the relationship of science and policy making, begging the question: How does the advent of OS change the science-society relationship? Starting from the assumption that understanding the prospects for Open Science practices to impact policy making first requires understanding the role of scientific evidence and researchers in policy making, the deliverable develops a research methodology for reviewing the relevant literature to answer the following broad research questions:

RQ1   How are Open Science outputs used in policy making?
RQ2   Which societal actors participate in RRI and Open Science policy making?

These objectives can be regarded as more generalized versions of the following questions:

- How does knowledge transfer work according to policy theory? What are the mechanisms of knowledge transfer identified in the literature?
- Which factors influence policy outcomes?
- What are the motivations of policymakers to use academic literature/research evidence?
- How do policy makers use scientific information? Do policy makers make (significant) use of OS outputs?
- What kind of evidence is given in the literature on these issues, e.g. surveys, focus groups (qualitative data) or quantitative data?

- Which contextual factors (such as political institutions, domain systems such as national health care, disciplinary contexts) impact the use of evidence by policymakers?
- How does (open) access to scientific results impact the use of evidence by policymakers?

Some of these questions go beyond the scope of ON-MERRIT. Additionally, as e.g. Ellen et al. (Ellen, Léon, et al. 2014) have suggested, empirical evidence to support claims about knowledge transfer mechanisms is hard to come by. Research question 2 concerns the methodology for tasks 5.2 and 5.3 associated with this work package, specifically the identification of (potential) survey respondents/interviewees. The research is timely and relevant, since there is yet little understanding of how OS impacts policy. Specifically, more light needs to be shed on the uptake of (open) scientific results by policymakers and the integration of deliberative policy making. How might increasing access to scientific literature (Open Access) or data (open or FAIR data[3]), increased transparency of experimental procedures (open methodologies), and increased accountability of scientific quality control (open peer review) affect research uptake in policy making?

1.3 Problem Definition: Can Policies be Evidence-based?

While the two main research questions are narrow in focus, they relate to a research field of considerable breadth. There are at least two bodies of literature to be considered (Contandriopoulos et al. 2010): One strand on the role of the sciences in society, the use of evaluation results, and rationalist management perspectives, and another strand on theoretical and empirical work in political science on the use of information by interest groups in policy making processes (lobbying). It should be noted that all these issues have been studied from a diverse range of perspectives, including policy theory, political science, and science and technology studies (STS).

The concepts of knowledge and expertise are probably the most difficult to define here. Studying the nature of knowledge has a history stretching over 2500+ years, starting (at least) with Socrates and Plato and reaching all the way into 20th and 21st-century philosophy. Any attempt to understand how knowledge can inform (any sort of) practice will implicitly or explicitly take a stance within this tradition. While we can merely touch upon these issues here, they should be kept in mind, nevertheless. In the literature we examined here, "knowledge exchange" implicitly rests on the assumption that knowledge must be evidence-based (Contandriopoulos et al. 2010). Knowledge translation implies a more interactive process than knowledge transfer which imagines a linear process (Grimshaw et al. 2012). The idea that policies should be based on the best scientific evidence available can be traced back to the establishment of the evidence-based medicine (EBM) framework in the 1970s (e.g. (Abekah-Nkrumah et al. 2018). One of EBM's core tenets was that clinical practice should be informed by clinical evidence (ibid.), a requirement which has subsequently been extended to and calls upon policymakers and other non-specialists to refrain from relying on ideology and common sense when developing policies. What constitutes evidence is a matter of considerable debate, however (ibid. p. 2). The health policy area has well-developed problem definition:

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[3] The FAIR guiding principles mandate that research data be made Findable, Accessible, Interoperable, and Reusable (Wilkinson et al. 2016).

"According to NICE, scientific evidence arises from explicit (codified and propositional), systematic (use of transparent and unambiguous methods for codification), and replicable (use of methods that can reproduce results in similar circumstances) scientific methods. On the contrary, colloquial evidence arises from expert testimony or comments from practitioners and stakeholders that may be crucial in complementing scientific evidence. Within the innovation literature, evidence is also argued to include experiences or received wisdom of individuals [9]." (Abekah-Nkrumah et al. 2018)

1.4 Data Collection and Literature Search

In order to answer the first research question, a systematic literature search was conducted based on standardized keyword lists. This search generated a total of 491 hits after initial elimination of unsuitable or irrelevant literature. Out of those 491 texts, 73 articles were selected for analysis based on relevance.

1.4.1 Construction of Search Terms

The literature review was conducted in five steps: 1) searching for abstracts/titles, 2) selecting articles through a rating of relevance based on abstract and keywords, 3) hand-selecting articles from the sample so-generated based on references to (aspects of) Open Science/RRI, 4) summarizing and validation of the literature so identified, and 5) synthesis. The search strategy details how the source material for the report was identified. Database research requires the definition of concepts and their subsequent operationalization through one or more search terms. Table 1 below specifies how search terms for the database search were constructed:

Open Science	Responsible Research and Innovation	Uptake	Impact	Information-seeking Behaviours	Policy-Making	Matthew Effect
Open Access	RRI	Absorption	Effect	Information-seeking strategies	Policy Design	Cumulative Advantage
Open Data	RRI indicators	Receptivity	Consequence	Information strategies	Policy Development	
Open Peer Review	MoRRI indicators	Capacity to absorb	Influence	Knowledge-seeking	Policy Mak*	
Open Methodologies	SuperMoRRI	Reception	Leverage	Knowledge-seeking strategies		
Open Science Outputs	Responsibility	Absorptive capacity	Clout	Research strategies		
Citizen Science	Accountability	Knowledge Exchange	Enhanc*	Literature Research		
		Knowledge Transfer		Evidence		
		Participat*		Evidence-based		
		Research Utilization				
		Knowledge Brok*				
		Policy Gap				
		Policy Advice				

Table 1: Overview of Search Terms

The rationale of the literature search was to begin with those terms that appear in the ON-MERRIT proposal (row 1) and then to define synonyms (columns). For the database search, the terms in the first row were combined using the AND-function (Boolean operator), while search terms in the columns (which give synonyms or sufficiently similar concepts) were combined using the OR-function. As of February 2020, the following databases have been searched with a preference for English-language, Open Access (or at least accessible through the library at our institution) articles and books:

- TU Graz Library Search (all databases) – joint search across the entire library catalogue (all printed works, e-books and journals the TU Graz library subscribes to)
- Scopus (all databases)
- Web of Science (all databases)
- PubMed

The sample was further reduced by checking title and abstract for relevance. Table 2 below gives an exemplary literature search string, along with the relevant concept and operationalization. It should be noted that the rules for forming search terms differ slightly across different sources. The example below is taken from a search in Web of Science:

	Uptake	Policy Making
Concept	Knowledge Transfer Knowledge Exchange Policy Gap Policy Advice	
Search Terms	"Knowledge Transfer" "Knowledge Exchange" "Policy Gap" "Policy Advice"	"Policy Making" "Policy Design" "Policy Development" "Policy Maker*
Example (Web of Science)	("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*") AND TOPIC: ("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice") Refined by: TOPIC: (Open Science)	

Table 2: Construction of Search Strings

1.4.2 Overview of Search Terms

Table 3 in the annex summarizes the search strings employed as well as their development and refinement over time. Using "Open Science" as a primary search term did not yield significant results. Therefore, we decided to pursue a different strategy. Instead of searching for references to knowledge transfer and use of evidence in policy making within the body of literature indexed by "Open Science", we went from the opposite direction to search for references to OS (practices) within several literatures pertaining to knowledge transfer and policy making.

Note that the three ON-MERRIT case studies (agriculture, climate, health) do not appear in the keyword searches. This is strategic; leaving out these and related keywords allowed us to study how the issues are being framed in different disciplinary/problem contexts. As we will show in due course, research uptake ("evidence-based policy making") is problematized to a much larger degree in some areas than others (e.g. in public health, cf. Oliver et al. 2014). For an overview of the search strings we used, see the annex to this scoping report (section 6).

1.4.3 Inclusion and Exclusion Criteria

Decisions regarding the inclusion or exclusion of articles were made either "on the spot" by assessing their usability based on title and abstract or by saturation (to avoid duplication). Initially, articles were categorized thematically according to dominant research questions, yielding a total of 9 categories:

1) Understanding/Improving Knowledge Transfer and Exchange
2) Open Science and Knowledge Transfer
3) How to improve knowledge transfer between researchers and policymakers ("bridging the (implementation) gap", "reducing the research-policy gap")
4) Policy Advice by researchers, communication strategies and aims
5) (Public) Health [by far the biggest chunk of the literature is health-related; the discussion about the science-policy-gap seems most developed there]
6) Policy-development process (How does it work, what is at stake etc.)
7) Perceptions of policymakers, perceptions of researchers
8) Political and institutional aspects of research use in policy making
9) Articles that develop frameworks to help researchers influence policy

The overwhelming number of these articles comes from the field of (public) health. The number is significantly smaller than the number of articles considered in the initial literature search. Articles that understood "policy making" in terms of research policy (and not, e.g. health policy, climate/environmental policy) or policies to promote OS while leaving the question how scientific expertise can be a basis for policy making untouched were not included in the report, e.g. (Smart et al. 2019). One important downside to the methodology employed in the literature review is that it only identifies those areas that define research uptake as a problem, leaving out fields that employ a different problem definition. Effectively, this means that fields which do influence policy making but where the mechanisms are taken for granted are possibly absent from this review.

1.5 Synthesis Approach

1.5.1 Analytical and Narrative Review

The main aim of this deliverable is to understand the role of OS in knowledge transfer from academia to policy makers. Our strategy thus consisted first in identifying and assessing the relevant literature on research uptake, summarizing the most salient findings and looking for references to Open Science principles and practices (e.g. Open Access, FAIR Data, tools, and infrastructures). The overall approach was intended to do

justice to demands on replicability as well as involving comparative and thematic synthesis rather than quantitative analysis. The literature was restricted (1) to all (peer-reviewed) materials pertaining to policy making plus (at least) one of the three ON-MERRIT use cases (agriculture, climate, health), (2) within that corpus all materials referring to (aspects of) OS and RRI. For the literature analysis, a triaging approach was used to keep the amount of data to a useable minimum (following the approach proposed by Contandriopoulos et al. 2010, 453). All authors of this report reviewed each other's work. The data are mostly narrative (i.e. in the form of published research articles), so the primary analysis strategy was also narrative, using article synopses to produce a synthesis document with a focus on how knowledge transfer is being problematized with respect to OS practices. Combining a summary approach and an analytical approach enabled giving due consideration to various literatures. Whereas a narrative analysis of the literature was used in those cases where the focus was on problem definitions/problem development as well as contextual factors, a summary approach was employed where the focus was on transporting commonalities of the articles, common findings and identification of causal mechanisms (of knowledge transfer). The integration of the literature was then concentrated on three sets of dimensions, two analytical, i.e. developed in the course of preparing the literature review and one summative, i.e. summarizing the dimensions emerging from the research under review. Aspects of OS (e.g. access to scientific literature, stakeholder involvement) were treated as analytical dimensions as well.

1.5.2 Themes and Structure of the Deliverable

Section 2 presents the results of a systematic literature review on research uptake in selected policy areas. Summarizing evidence on barriers and facilitators to research uptake, the section finds that proposed strategies to "bridge the gap" include improving communication and other forms of interaction between researchers and policy makers (Choi et al. 2016; Merlo et al. 2015; Brownson and Jones 2009). The respective body of literature draws on an overly idealized image of the policy process (Cairney 2016), leading some (e.g. Cairney, Oliver, and Wellstead 2016) to suggest re-evaluating the evidence-policy gap based on insights from policy theory. Building on Weiss's (Weiss 1979) knowledge transfer typology, the section describes aspects of the policy process conducive to research utilization, closing with the prospects of Open research outputs to influence policy processes. Section 3 suggests that both Responsible Research & Innovation (RRI) and OS be best understood as continuing earlier academic interest in the science-society relationship, an interest as old as modern science itself. Summarizing historical developments of conceptions of the science-society relationship, section 3 suggests that some elements of RRI/OS have been part of earlier attempts to understand the relationship (Technology Assessment, Mode 2 Science, Policy Advice). All these, including RRI and OS, constitute not simply descriptions of the science-society relationship but must be understood as attempts to re-negotiate the role of science in society. Section 4 summarizes the findings to suggest that improved infrastructure for sharing scientific outputs could have a positive impact on the use of evidence in policy making and introduces a set of methods to be used in ensuing research tasks 5.2 and 5.3 associated with this work package. Following section 5 (References), section 6 (Annex) details the search strings used for the systematic literature review, as well as including a (tentative) exposition of research instruments (survey and interviews).

2 The Impact of Open Science on Policy Making

2.1 Knowledge and practice: Research, Policy making, and the Evidence-Policy-Gap

The key question to be explored in more detail concerns the uptake of Open Science (OS) outputs in policy making. This question can be regarded as a variant of the more general issue of research utilization or research uptake in policy making. Whereas in earlier decades, public service had a monopoly over policy advice, public servants are now expected to consult external sources (academia, stakeholder organizations, think tanks, political organizations) (Head 2015). The Evidence-Based Policy (EBP)-movement that developed in the 1970s and regained momentum in the 1990s was instrumental in this regard, as it sought to promote rigorous analysis of policy options and programs (Head 2016). Governments increasingly rely on advice and (scientific) evidence to improve governance resp. governability (Hermann et al. 2015), which is particularly true of certain (i.e. neo-corporatist) political cultures. This situation has led to increased interest in understanding the interlinkages between policy making and expertise (Lundin and Öberg 2014).

The goal of research in government is to find information that will help to solve a specific, predefined policy problem in real time (Glied, Wittenberg, and Israeli 2018). One of the most salient issues in the literature examined here concerns the fact that topical scientific expertise is not used in respective policy decisions despite its availability (Graham et al. 2006; Haines, Kuruvilla, and Borchert 2004). This problem has been dubbed the "evidence-policy gap" and has even been singled out as a major obstacle in reaching the UN's sustainable development goals in public health (Panisset et al. 2012). Discussions of the evidence-policy gap appear to be very mature in the health policy literature (Brownson and Jones 2009; Cairney, Oliver, and Wellstead 2016; Choi et al. 2016; Dodson, Geary, and Brownson 2015; Ellen et al. 2018; Gollust, Seymour, Pany, Goss, et al. 2017; Haynes et al. 2011; Oliver et al. 2017). This is unsurprising given what the bulk of this literature has to say on policymakers' sources of information (Dodson, Geary, and Brownson 2015; Ellen et al. 2018; Gollust, Seymour, Pany, Goss, et al. 2017; Haynes et al. 2011). The relationship between policymakers and researchers is frequently described as one of mutual misunderstanding or even outright mistrust (Haynes et al. 2012). Reasons presented are manifold and range from fundamentally different goals and values to differences in communication style (e.g. Merlo et al. 2015). In fields such as agriculture or climate research, awareness of a possible evidence-policy gap appears to be lower (but see e.g. Hooper, Foster, and Giles-Corti 2019). For the present purpose, it will be helpful to look more closely into how the existence of an evidence-policy gap is justified empirically.

In public health (policy) literature especially, barriers to research utilization in policy making are studied under the general heading of an evidence-policy gap or, less often, a research implementation gap (Haines, Kuruvilla, and Borchert 2004). As Paul Cairney (2016, 8) has pointed out, however, scholars have only recently begun to appreciate the important distinction between pathologies pertaining to all policy making processes and more specific issues that can be addressed to reduce the gap when studying the barriers to research utilization. The main obstacles for research utilization by policymakers identified in the literature are limited access to relevant, good quality research, lack of timely research output (e.g. Oliver et al. 2014), lack of adoption (e.g. Olesk, Kaal, and Toom 2019 for the case of Estonia), and conflicting logics for policy making and research (goals and success criteria) (Gollust, Seymour, Pany, Goss, et al. 2017; Haynes et al. 2012; Holm

and Ploug 2015). Jasanoff (1997) pointed out that different stakeholder groups involved in policy processes differ in their stakes in determining how policy-relevant science should be interpreted (and by whom) and what should be defined as policy-relevant science. Each group (and sub-group) thereby attempts to retain the right to define the border between science and policy, and each does so in a way that stakeholders believe will further their own interests. There is considerable disagreement in what the role of evidence should be (see e.g. Allen 2017); variations in perceptions of the role of evidence are attributed to individuals, organisations, sectors, and issue areas.

The following sections draw on an established review (Oliver et al. 2014) to reconstruct how the evidence-policy gap is described in the empirical literature. Following work by Cairney (2016) and Cairney et al. (2016), we argue that the evidence-policy gap is frequently invoked based on an overly simplified understanding (i.e. uninformed by policy theory) of how policy processes work, a deficit with considerable spillover into the kinds of recommendations included in this body of literature on how to close the evidence-policy gap such as improving the quality and accessibility of academic publications (Oliver et al. 2014; Oliver, Lorenc, and Innvær 2014), improving communication (e.g. Dodson, Geary, and Brownson 2015) and community-building on the part of researchers (Haynes et al. 2012). We thus consider three analytically distinct (but thematically connected) discourses:

- Problem Diagnosis: Empirical evidence for the evidence-policy gap (mostly qualitative, i.e. interviews and surveys) leading to a substantiated problem formulation
- Advocacy and Recommendations: Normative discourse and recommendations for practitioners (in this case, "practicing" scientists) on how to "bridge the evidence-policy gap"; importantly, only researchers are represented in the literature (i.e. neither policymakers nor advocacy groups collaborate on research design, analysis or publications)
- Critique: The diagnosis of an evidence-policy-gap results from a specific problem definition and analysis; the framework is ultimately normative (research should inform policy) and built upon a rudimentary (common sense) understanding of policy processes

We begin by developing the hypothesis that the problem diagnosis is founded in a specific problem definition. The notion of a gap implicitly contends that there are (at least) two distinct groups (researchers and policymakers) with competing goals, values, and languages etc. who should be communicating but, for reasons developed in detail in the literature, don't succeed in doing so (e.g. Cairney, Oliver, and Wellstead 2016). Both the policy gap diagnosis and the model of two cultures (academia and policy) are methodical artefacts in this perspective (Oliver, Lorenc, and Innvær 2014).

2.2 Knowledge Transfer: Empirical Evidence on Barriers and Facilitators

Barriers and facilitators to knowledge transfer are a well-recognised research topic in the literature (Mitton et al. 2007, 735) and there seems to be consensus on a set of results. In fact, the bulk of the literature on knowledge transfer pertains to barriers and facilitators to evidence-based policy making (Lavis et al. 2003; Mitton et al. 2007; Oliver et al. 2014). The following section describes the literature and evidence on the evidence-policy gap as discussed in the health-policy literature in more detail. It shows how the issue has

been researched and summarizes the most salient findings. The most frequently identified barriers and facilitators to research uptake are

- policymakers' communication and information-seeking behaviours
- researchers' (lack of) understanding of the policy process
- policymakers' (lack of) understanding of research outputs and
- incompatibility of researchers' and policymakers' values and goals.

Research into knowledge transfer is defined either as "the study of methods to promote the uptake of research findings by patients, health care providers, managers, and policy makers" (Curran et al. 2011, 174) or as research into Knowledge Transfer and Exchange (KTE) activities undertaken by health systems and policy researchers (Ellen, Lavis, et al. 2014) The "gap" is introduced in various ways, including a) assertions of failure to implement cost-effective health interventions and a corresponding need to promote interactions between researchers and policymakers (Haines, Kuruvilla, and Borchert 2004), b) descriptions of ways of enhancing the uptake of evidence-based interventions and the potential of scientific discoveries (Brownson and Jones 2009; Choi et al. 2016), c) claims of the (in)ability of public health services to integrate research findings into their decisions and operations (Cambon et al. 2017), d) rhetorical questions such as "Can Scientists and Policy Makers work together?" (Choi et al. 2005), e) attempts to understand why the utilization of research by policymakers is rarely fully realized (Dodson, Geary, and Brownson 2015, 840), f) the identification of barriers and facilitators to evidence-informed decision-making (Ellen, Léon, et al. 2014; Merlo et al. 2015) and g) the study of factors that facilitate or impede evidence-based policy making (Elliott and Popay 2000). Furthermore, there are more positive ways of addressing knowledge transfer processes such as h) the identification of pathways that link research and policy and that influence policymakers' use of health services research (Gold 2009), or i) in terms of understanding researchers' and policymakers' perspectives on their mutual collaboration (Gollust, Seymour, Pany, Goss, et al. 2017), j) in terms of guiding knowledge translation activities (Grimshaw et al. 2012), k) in terms of studying how policy-relevant research and natural experiments can be disseminated to policymakers to positively impact policy (Hooper, Foster, and Giles-Corti 2019); as well as l) in terms of an observed and inexplicable persistence of barriers to knowledge transfer (Oliver, Lorenc, and Innvær 2014).

In general, the literature builds on the assumption that researchers need to do a better job at understanding how policy processes work in order to influence policy (Macintyre 2012). Within the literature, three kinds of key actors are identified (Kim et al. 2018): Knowledge users (e.g. policymakers), intermediaries, and knowledge producers, in addition to three basic components of knowledge exchange systems: 1) the roles of individual actors (producers, intermediaries, users), 2) the nature of the knowledge exchanged, and 3) the process of knowledge use (Contandriopoulos et al. 2010, 454). Many models only concern two of the three types of knowledge-related roles (ibid. 455), i.e. users and producers, without taking account of intragroup diversity (ibid.). Additionally, the concept of "knowledge exchange" often implicitly rests on the assumption that knowledge by itself must be evidence-based (ibid. 456).

The respective literature is predominantly from the Anglo-Saxon political context (UK, Australia, and, to a lesser extent, the US as well as certain parts of Africa)[4]. It relies almost exclusively on qualitative methods, i.e. surveys and interviews with research users (politicians, civil servants, etc.) and research producers. Whereas Mitton and colleagues (2007) found that only a fifth of studies on knowledge transfer were "real-world" applications, more recent reviews find a growing empirical interest in the phenomenon. We predominantly relied on four systematic reviews of barriers and facilitators for the use of evidence by policymakers to structure this chapter (Cairney, Oliver, and Wellstead 2016; Liverani, Hawkins, and Parkhurst 2013; Oliver et al. 2014; Oliver, Lorenc, and Innvær 2014 are particularly relevant here). Based on a sample of N=145 articles, Oliver et al. (Oliver et al. 2014, 7) identified the most commonly reported barriers as:

- Contact, collaboration, and relationships: Collaboration, timing, relationships with policymakers, relationships with researchers, contact with researchers, contact with policymakers
- Organisational factors and resources: Availability/access to research, costs, managerial support, professional bodies, material resources, personnel resources, managerial will, staff turnover/continuity of employment
- Characteristics of research and researchers: Clarity/relevance/reliability/format/importance of research findings
- Characteristics of policymakers: Research skills, research awareness, political support, practitioner research skills/awareness, information-seeking behaviour
- Characteristics of the policy making process: Guidelines, importance of policy, legal/legislative support, other pressures on policy

We use these five themes to structure our analysis of the literature on research utilization and, more specifically, the evidence-policy gap. Contacts and relationships (social capital) are reported throughout the literature to be major facilitators of evidence use. According to Oliver et al. (2014, 4), timing and opportunity were the most important barriers, along with (dis)trust and mutual (dis)respect. Organisational factors (economic capital in the widest sense) such as (lack of) access to scientific results, (lack of) material and personnel resources and managerial support were frequently mentioned as well. These include inflexible and non-transparent policy processes, and (in developing countries) a general lack of effective health care systems (ibid. 4 f.) Concerning the evidence, the quality of research, its relevance and reliability as well as presentation formats were widely reported (ibid. 6). Researchers themselves were described as factors impacting the uptake of scientific evidence. Researchers' understanding of the policy process as well as differences in priorities (between research users and research producers) were described as important barriers to uptake. Generally, researchers' advice was valued more by policymakers when researchers were able to present themselves as unbiased and non-partisan. Regarding policymakers, lack of understanding/awareness of research was frequently reported as a barrier (ibid. 6). Personal experience, values and judgements were reported as important factors. In the literature reviewed by Cairney, Oliver, and Wellstead (2016), aspects of the policy process were scarcely reported as factors influencing the uptake of evidence. Even though the authors point out that here, a lack of evidence cannot not be taken as evidence

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[4] We acknowledge that this may be due to the literature search strategy being restricted to English language publications.

of absence, this finding should be kept in mind as a general lack of reflection on policy processes in the literature on the evidence-policy gap is often bemoaned (e.g. in Cairney, Oliver, and Wellstead 2016). In what follows, the reviewed literature is summarized with respect to interaction, organizational factors, characteristics of researchers and research, and characteristics of policymakers and policy making.

2.2.1 Interaction: Contact, Collaboration, Relationships, Trust, and Communication

The quality of relationships between researchers, policymakers and (sometimes) intermediaries is a well-recognized research area within the literature. Based on a systematic review, Oliver et al. (2014) found that collaboration between researchers and policymakers, along with improved relationships and skills were the most frequently reported facilitators of research uptake. Collaboration (particularly in the long-term) and trust-formation between researchers and policymakers may be hampered by the short-term nature of research work, which also relates to most researchers being employed on a short-term contract basis (Elliott and Popay 2000, 467). The type of collaboration was also found to be important: Upstream collaboration, i.e. collaboration that starts already at the stage of knowledge production, was found to be a desideratum of researchers and policymakers alike (Choi et al. 2016).

Additionally, mutual mistrust between researchers and policymakers has been recognized as a barrier to research use (Choi et al. 2005; Elliott and Popay 2000; Gold 2009; Gollust, Seymour, Pany, and Goss 2017; Haynes et al. 2012). Gollust and colleagues (Gollust, Seymour, Pany, and Goss 2017) found that researchers and policymakers harbour mutual distrust – policy makers question the credibility of research, and researchers question policy makers' authentic desire to use evidence in decision making. The two groups had varying perspectives on the value of research in policy making; negative aspects of the other's work corresponded with a high level of distrust for the other group. Researchers reported that competing demands on their time (e.g. knowledge transfer is not featured in tenure/promotion criteria) hampers effective communication with policy makers. Conversely, time constraints (though of a different kind) also keep policy makers from engaging with research ("deluge of information"). In general, the relationship between researchers and policymakers seems to be fraught with mutual mistrust (wherein both parties accuse the other side of vested interests) (Gollust, Seymour, Pany, Goss, et al. 2017).

According to a survey by Oliver and colleagues (Oliver et al. 2017, 122), academics are rarely represented in the networks" of policymakers. Policymakers' most frequent sources of information were local health experts, government websites and mid-level health service managers without any direct expertise in Public Health. Policymakers prefer opinion leaders; additionally, the latter tend to nominate each other as sources of information (as opposed to academics who are not central sources of information). Respondents said that they value researchers who exhibit credibility in three core areas of trustworthiness – a) competence (pragmatism)/reputation, b) integrity (faithful representation of research), and independence (more important to politicians), and c) benevolence/commitment (especially where policy directions have been decided) – trust is therefore critical.

The most trusted sources of information for policymakers are government sources as well as advocacy, industry and lobby groups; some policymakers mentioned experts (university researchers/healthcare professionals) as a trusted source of information (Dodson, Geary, and Brownson 2015, 844). A review found

that tailored messages in combination with accessible online registries of reviews had a significant positive effect on research uptake, and so did increased interactions between policymakers and researchers when research goals matched the beliefs, goals, values and policy aims of policymakers (Boyko, Kothari, and Wathen 2016). Oliver et al. (Oliver et al. 2014) found an increasing amount of research into new models of knowledge transfer; many studies discussed the serendipitous nature of the policy process which gives primacy to unplanned, informal contacts.

Communication of research comes with certain trade-offs: Clear writing tends to make research more accessible, but at increased cost for researchers who invest more time and other resources (Merlo et al. 2015).

2.2.2 Organizational Factors and Resources

Knowledge Transfer (KT) is deeply embedded in organizational, institutional and policy contexts, which means that the efficacy of KT strategies should be judged with respect to these contexts (Contandriopoulos et al. 2010, 468). Australian surveys have found that organizational context plays an important role in how relationships between academia and government evolve (Head 2015, 7). A lack of resources on the part of scientists is among the most frequent barriers to promoting evidence-based policy advice, as well as low policy relevance of research and lack of strategic thinking (Cairney, Oliver, and Wellstead 2016, 400). On the other hand, timely access to good quality research, collaborations and relationship building are reported to be the most important factors conducive to research uptake. Conversely, the most frequently reported barriers are poor access to good quality relevant research and lack of timely research output (Oliver et al. 2014). Policymakers use information other than research evidence which might be more relevant and timelier (Oliver, Lorenc, and Innvær 2014). Systematically, the focus on research users' access to research outputs addresses the problem of uncertainty in policy making (Cairney, Oliver, and Wellstead 2016); policymakers need access to relevant research to be able to make well-informed decisions (Cambon et al. 2017). Accessibility thus influences research uptake (Contandriopoulos et al. 2017), putting constraints on policymakers' abilities. For researchers, this means that information and data should be kept in an accessible format (Dodson, Geary, and Brownson 2015). In a study of Estonian policymakers' use of evidence, Olesk et al. (2019) found that lack of access is perceived as an impediment in commissioning new studies, and costs associated with access to databases are an issue for government bodies. Oftentimes, those tasked with compiling policy-relevant research make use of their university affiliations to circumvent this problem (ibid.). Organizational barriers to research uptake further include organizational constraints, influence of fads and trends on the policy process (Weiss 1979), corruption and ideology as well as cultural beliefs (Haines, Kuruvilla, and Borchert 2004). Ellen and colleagues (Ellen, Lavis, et al. 2014) found that the most frequently identified organizational barriers to research uptake were limited resources (financial or personnel), time constraints (to make decisions or participate in training, e.g. regarding use of databases), high staff turnover rates and institutional resistance towards change. On the other hand, willingness on the part of decision makers to create a culture of knowledge translation and to invest resources was frequently mentioned as a big facilitator. Organizational differences in time commitment are frequently found to be a barrier for research uptake (Kothari et al. 2011, 205). Hermann et al. (2015) claim that in certain organizational cultures (their study looked at Austrian neo-corporatist political culture), science-policy interactions lack transparency, which the authors also attribute to the prevalence of informal contacts between policymakers

and researchers. Formalized advice through contract research does not promote transparency of procedures and criteria. Ministries frequently prefer not to publish commissioned research, and scientific input is generally treated as internal concerns (i.e., not publicly accessible). This entails that recommendations formulated by committees remain invisible. Another case in point is that in recent years, the shift from contract research to research programs has boosted transparency regarding beneficiary institutions, funding amounts, topics and publication of results (Hermann et al. 2015). Organizational culture in policy making has a temporal dimension which is ill-attuned to academic influence. The timescales of government requirements tend to be shorter than those of academic research (Head 2015); on the other hand, policy advice might have a long-term impact on organizational culture and perspectives of policymakers (ibid. 7). Research utilization needs to be understood in temporal terms; researchers should not expect that knowledge transfer produces immediate and measurable results (Blewden, Carroll, and Witten 2010). Therefore, the most common advice for researchers is to build better communication channels and closer relationships (interactive approach) (Glied, Wittenberg, and Israeli 2018; Gold 2009; Grimshaw et al. 2012; Head 2015). Patterns of evidence use and management vary across domains and across organizational types (policy development, service delivery, regulatory oversight) (Head 2016), but are also an effect of the content of the policy field, as the example of climate adaptation versus climate mitigation shows (Hermann et al. 2015).

2.2.3 Characteristics of Research and Researchers: Clarity, relevance, reliability, format and importance of research findings

Researchers' ingrained traditions of communication (via peer-reviewed publications) are ill-attuned to the needs of policymakers in terms of seeking researchers' advice. Policymakers identify potential experts based on their engagement with literature (this pertains mostly to policymakers in research-related roles), through conferences, personal networks and past committee memberships, and sometimes through self-identification of researchers (though this seems to be somewhat less prominent). Policymakers often turn to the Internet first to seek information (Dodson, Geary, and Brownson 2015). Formal procedures to identify experts are rare; if anything, "pools" of potential consulting experts are stagnant. Haynes and colleagues (Haynes et al. 2012) further found that politicians tend to see researchers as a subgroup of experts (regardless of their professional role), i.e. policymakers in the sample did not differentiate between academics and other professionals who they reach out to. Experts are recruited primarily through personal networks and advisors. Interestingly, expert selection is often based on media presence and reputation (e.g. past involvement in policy processes) which might suggest an effect of cumulative advantage (Merton 1968). Understanding of policy processes on the part of researchers was also regarded as an important selection criterion. In general, the ability to communicate clearly and concisely is highly valued in researchers (Haynes et al. 2012). Factors limiting the translation of findings from economic evaluations into healthcare policy include poor quality of research, assumptions used in economic modelling, difficulties in resource transfer, and negative attitudes to healthcare rationing (Merlo et al. 2015).

Head (2015) distinguishes four kinds of policy-interested academics: 1) mainstream academics providing commentary on governance trends, 2) academics who specialize in providing evidence-informed critiques of government policies who are usually ignored but may make an impact in the long run, 3) academics who provide applied research consultancy services and technical advice, and 4) academics who take on advisory roles within public agencies. Systematic reviews are regarded as fundamental in transferring evidence from

medical and health research to health policy making (Abekah-Nkrumah et al. 2018; Marquez et al. 2018; Tugwell et al. 2006). For instance, Tricco and colleagues (Tricco et al. 2016) found that authors of systematic reviews are expected to provide tailored summaries with key messages to policymakers. Whether academics participate in policy making and to what extent is a matter of the political context (Hermann et al. 2015). Local and organisational context dictates the realm of the possible for knowledge exchange strategies aimed at influencing policy making (Cambon et al. 2017; Contandriopoulos et al. 2010).

Some studies criticise a lack of institutional incentives for carrying out and synthesizing research according to policymakers' needs (Abekah-Nkrumah et al. 2018). Formal structures and mechanisms within research-performing institutions to collect and synthesize information, along with mechanisms to make these syntheses available, would be an important facilitator to research uptake (Abekah-Nkrumah et al. 2018). This is an option where there is still potential in most cases (Gold 2009). Grimshaw and colleagues (Grimshaw et al. 2012) suggest that the basic "unit" of research translation should be up-to-date systematic reviews or syntheses of research findings, as they are easier consumed (at least if well-written) and less likely to be biased than research articles; translators are needed to deliver these outputs in ways easily digested by target audiences; there is a range of informative systematic reviews of factors important to research use by professionals and interventions aimed at different groups; evidence translation is too rarely based on evidence (Grimshaw et al. 2012). However, public engagement with research requires a public that is both informed and active; even where systematic reviews are available, they need to be translated for patients and health professionals (Haines, Kuruvilla, and Borchert 2004). Researchers' and intermediaries' translation skills ("elevator test") are particularly important in this regard (Gold 2009). Boyko and colleagues (Boyko, Kothari, and Wathen 2016) found that tailored messages in combination with accessible online registries of reviews had a significant positive effect on research uptake.

Merlo et al. found that research evidence needs to be accessible (to potential users) and acceptable (in terms of the evidence provided) (Merlo et al. 2015, 303). Accessibility refers to the possibility on the part of policymakers to make timely use of economic evidence; acceptability can either mean scientific acceptability (valid methods, unbiased results, modelling assumptions), institutional acceptability (evidence meets the institutional needs of the decision maker), or ethical acceptability (Merlo et al. 2015). There are trade-offs between the accessibility (for policymakers) and the acceptability (for researchers) of research findings such that while e.g. the use of a sophisticated statistical apparatus might improve the acceptability of a certain evidence base it might do so only at the cost of decreasing its accessibility to a non-expert audience. (Merlo et al. 2015). Similar for external research funding (e.g. through industry partners) which may increase accessibility but may be regarded as harming scientific acceptability (Merlo et al. 2015).

Concerning the role of the public and patients, Haines and colleagues (Haines, Kuruvilla, and Borchert 2004) argue that more systematic forms of exchange could enhance the uptake of health-related research. Therefore, the authors find that more work is needed in translating research evidence for practitioners and health professionals. The study identifies an extensive list of other relevant barriers to uptake which includes financial barriers (inadequate funding or incentives), organizational constraints, failure of curricula to reflect evidence, lack of incentives to participate, influence of fads and trends, corruption & ideological beliefs, and cultural beliefs (Haines, Kuruvilla, and Borchert 2004).

2.2.4 Characteristics of Policymakers: Research skills, research awareness, political support and practitioner research skills

Policymakers do not constitute a clearly defined group (Saretzki 2019), but rather involve such diverse actors as politicians, public servants, administrators, and (sometimes) lobbyists and interest groups. "Policymaker" thus denotes a rather heterogeneous group. Evidence helps decision makers to reduce uncertainty, but policymakers rely on beliefs and emotions to reduce ambiguity by choosing a certain problem interpretation (Cairney, Oliver, and Wellstead 2016).

Policymakers' skills in terms of the ability to find and make sense of evidence are frequently found to be a facilitator to research uptake (Cambon et al. 2017; Oliver et al. 2014). Conversely, lack of such skills is often bemoaned as an ostensive barrier to uptake. Policymakers frequently struggle with knowledge management and a lack of skills to appraise research (Ellen et al. 2011; Head 2015, 7), in addition to a lack of equipment or financial resources, knowledge, attitudes, and skills to utilize research (Ellen et al. 2011). Policymakers' needs were frequently reported to be ill-attuned to what research can offer (e.g. Abekah-Nkrumah et al. 2018, 21). Additionally, policymakers' attitudes (e.g. distrust) towards research can be a barrier (Ellen, Lavis, and Shemer 2016).

Access to data and other research outputs (systematic reviews, individual studies, grey literature) is therefore deemed insufficient to fostering research uptake; expertise on the part of policymakers in terms of e.g. data interpretation and analysis is deemed desirable (Lillefjell and Knudtsen 2013). Dodson and colleagues (Dodson, Geary, and Brownson 2015) found that policymakers seek certain kinds of information from certain kinds of people; most of their informants sought data and statistics (demographics of diseases) on prevalence of health issues to understand the severity of an issue (Dodson, Geary, and Brownson 2015, 842); however, the kind of information sought depends on the particular functional role of a policymaker (whether policy development regulation, or service delivery) (Head 2016, 475). In general, policymakers seek information that is timely, relevant, credible, and available (Head 2015, 7).

In comparison, university personnel and extramural academics play a much less important role. Oral forms of communications are more commonly used than written material. A study of knowledge transfer in Israel found that policymakers prefer receiving information through personal contact (Oliver et al. 2017, n. 22). The most trusted sources of information are government sources as well as advocacy, industry and lobby groups, though some policymakers also mention experts (Dodson, Geary, and Brownson 2015, 844). Policymakers trust their networks and personal contacts above all for information (Oliver et al. 2017). Policymakers' awareness of research is low, and few academics participate directly in the process of decision making (ibid.). Information does not come primarily from academic publications. Rather, policymakers prefer governmental agencies and websites. Nevertheless, the literature consistently finds that the main factors to improve research uptake are access to relevant and clear information and good relationships between researchers and policymakers (Oliver, Lorenc, and Innvær 2014). Given these preferences, the availability and accessibility of written information in the form of scholarly publications is of secondary concern (Oliver et al. 2017). Policymakers prefer face-to-face interaction to reading research reports or publications (Haynes et al. 2012).

Actors providing policymakers with advice have received increasing scholarly attention in recent years (Christensen 2018, 295). The public policy literature refers to these actors and institutions as "policy advisory

systems". These advisors can be classified according to their location, i.e. inside or outside public bodies (ibid.). In the policy arena, the current landscape with respect to knowledge transfer thus includes a set of (more or less) formalized roles (depending on national trajectories and cultures), "from advisory councils and committees to the position of chief scientific advisor" (Olesk, Kaal, and Toom 2019, 3). How these roles are being interpreted by their holders is a matter of empirical investigation. The bibliography is rather slim here, though Haynes et al. (2011) find that interaction of researchers and policymakers crucially depends on the position of the policymaker within the policy making process (whether they are politicians, civil servants etc.).

Governmental advisory bodies are spread (a) across fields of expertise, (b) across government offices and ministries (sometimes those overlap with fields of expertise) (Olesk, Kaal, and Toom 2019). In the case of Estonia, Olesk and colleagues found, studies commissioned by ministries are one of the main vehicles of knowledge transfer from research to policy. However, studies commissioned by policymakers are frequently left unused in the policy process and reports are not publicly available (Hermann et al. 2015). Additionally, the studies themselves are often poorly commissioned and there is a lack of coordination between ministries (Olesk, Kaal, and Toom 2019, 3). Newman et al. (2016) point towards divisions within the policy community (and there are very likely also divisions in this sense in the scientific community), e.g. between policymakers and administrators.

2.2.5 Characteristics of the Policy-making Process: Guidelines, importance of policy, legislative support, other pressures on policy

The policy context plays a crucial role for the use of evidence (Blewden, Carroll, and Witten 2010; Contandriopoulos et al. 2010; Glied, Wittenberg, and Israeli 2018; Krick 2019). Policy making is described as an unpredictable, long-term, multilevel process involving networks of policymakers, paradigms, norms and (sometimes) quick succession of priorities (Cairney, Oliver, and Wellstead 2016, 400; Paul Cairney and Rummery 2018, 544). Accessibility depends on the timeliness of research, communication, and decision makers' level of understanding; Acceptability depends on the accuracy and validity of research methods, institutional structures, and ethical concerns (Merlo et al. 2015). There are cultural differences with respect to the inclusion of academics and interest groups into the policy process: In Estonia, Olesk and colleagues found, the participation of scientists and other stakeholder groups "is common in the preparation of various policy strategies and development plans. These strategy documents, however, tend to be poorly aligned with each other […] and rarely end up being fully implemented" (Olesk, Kaal, and Toom 2019, 3) There are thus three common fields of engagement for academics in the policy process: a) preparation, b) implementation, and c) coordination on policies.

Smits and Denis (2014) point out that users of scientific evidence may not just be researchers and policymakers. Rather, the group includes actors from a diverse array of fields such as end users (with respect to medical research, these would be e.g. medical practitioners and patients); decision makers in politics, funding agencies, and business; politicians and civil servants.

Elliott and Popay (2000) find that sustained dialogue between researchers and policymakers is essential in securing research uptake; the interaction model more fully grasps the more subtle mechanisms of knowledge transfer compared to the problem-solving model (Weiss 1979). Researchers' critical perspective and

credibility can only fully develop in an environment that facilitates dialogue and enables researchers to acquire in-depth knowledge of the policy process (Elliott and Popay 2000, 467; Glied, Wittenberg, and Israeli 2018). This aspect of the problem is a variant of the differences in timescales criticised in e.g. (Blewden, Carroll, and Witten 2010; Paul Cairney and Rummery 2018; Choi et al. 2005; Ellen et al. 2011; Ellen, Lavis, and Shemer 2016); time constraints of the policy process constitute the other side of the same coin (Gollust, Seymour, Pany, and Goss 2017).

Lundin et al. (2014) found that the use of expertise by policymakers is more pronounced when there is a lot of public attention or political controversy; however, in such circumstances, policymakers are also less prone to deliberation and critical reflection (and to change their opinion) on the information provided.

Some studies find that currently, there are no institutional structures to identify research needs and communicate them to researchers (Abekah-Nkrumah et al. 2018, 19). The propensity of organisations for research uptake depends on their ability to put in place formal as well as informational structures for organisational learning (ibid. 2). In a systematic review, Liverani et al. (2013) conclude that three aspects of political institutions are relevant to the use of evidence in public health: 1) the level of centralization of government, 2) the influence of external organisations (e.g. intermediary organizations including lobbyists and interest groups), 3) the organisation of bureaucracies.

Merlo et al. (2015, 305) report that policymakers and healthcare practitioners repeatedly recommend that researchers (health economists in this case) demonstrate better knowledge of the policy-process, because economic evaluations of policies routinely ignore concerns faced by decision makers such as feasibility concerns.

2.2.6 Discrepancies in Norms, Values, and Goals

The policy process is inherently political, and necessarily depends on policymakers' preferences as well as their adherence to goals and values (Head 2016, 473; Kothari et al. 2011, 204). These "deliberative" aspects of the policy process cannot be accounted for in "linear" (problem-centred) models of knowledge transfer (Elliott and Popay 2000, 467), as it entails that neutral scientific evidence cannot drive policy in democratic systems. The political process is marked by conflict, evidence is used to make arguments about ends and means (Head 2016, 473). Whereas researchers tend to work with clearly defined problems, policymakers need to address an entire problem in all its complexity (Kothari et al. 2011, 204). Therefore, policymakers are motivated by factors other than research evidence (Head 2016, 474).

These discrepancies make collaboration prone to conflict and have led some (e.g. Choi et al. 2005) to question whether researchers and policymakers can work together. Collaboration tends to run more smoothly when research goals match the beliefs, goals, values and policy aims of policymakers (Boyko, Kothari, and Wathen 2016), an observation that directly contradicts demands of neutrality. The evidence-policy gap is often linked to this sort of cultural gap (Paul Cairney and Rummery 2018, 544). Exemplary results are presented in what follows. Gollust and colleagues (Gollust, Seymour, Pany, Goss, et al. 2017) found that researchers and policymakers had varying perspectives on the value of research in policy making, even though both groups are faced with the same barriers with respect to research translation (lack of dedicated time to engage in

research translation and mutual distrust). However, both groups expressed a mismatch between what policy makers need and what research can deliver.

Discrepancies in norms and values are consequential for how the potential for research uptake is perceived. Martin and colleagues (2011) found that researchers and policymakers offered competing accounts of research knowledge (as a product or outcome or as a mindset for solving problems, respectively), and Ellen et al. (2018) found that policymakers tend towards the view that research uptake faces practical constraints, while researchers think that utilization is hindered by lack of coordination between knowledge users and producers.

Finally, evidence never directly solves policy problems, but needs to be embedded first in action proposals (Contandriopoulos et al. 2010, 459). Therefore, the mere internal validity of information (arguably a defining feature of knowledge) does not by itself influence the use of information (ibid. p. 457). This lack of connection might be due to the oft-observed relevance only of external validity (i.e. relevance of evidence to a specific policy context).The use of knowledge is therefore a function of its relevance to a given policy context (see also Weiss 1979), legitimacy (both of the knowledge and of the knowledge producers), and accessibility (Contandriopoulos et al. 2010, 460). Both producers, intermediaries and users invest resources into knowledge exchange to the extent that they deem this exchange profitable (Contandriopoulos et al. 2010, 462).

In any case, even in those cases where the impact of scientific evidence on policy advice is evident (e.g. Christensen 2018), it is not clear whether changes in the culture of policy advice have an impact on policies. In a study of the role and use of philosophical (read: ethical) evidence in reproductive medicine, Holm and Ploug (2015, 8) point out that policy-making and philosophical analysis are activities with different goals and success criteria. The same can be said for research more generally. In addition to having to answer questions of implementation, policymakers need to worry about being re-elected and are under pressure to strike compromises between competing groups. All these factors put limits on the extent to which policies can be evidence-based.

Interestingly, despite the incompatibility of their goals, both policymakers and researchers are concerned with bias: While policy makers worry about bias in research, researchers qualify the non-research-factors in the policy process as biased (Gollust, Seymour, Pany, and Goss 2017). Merlo et al. (2015) found a tension between academic standards of rigour and the realities of policy making; the existence of trade-offs implies that strategies to overcome one barrier may have adverse effects for overcoming other barriers.

2.3 Methods of Research into the Evidence-Policy Gap

There is thus a large body of literature on the barriers to the use of scientific evidence in policy processes. However, as Cairney (2016) points out, most of this work has the tendency to assert the existence of the gap and propose recommendations rather than attempting to develop a more systematic account of the problem based on policy theory. Most of the empirical work is case based (with a focus on a single piece of policy) without much ethnographic contextualization of the multi-faceted processes underlying policy development (Oliver, Lorenc, and Innvær 2014, 4). A large proportion of the respective research has a normative dimension

as it focuses on how to increase research uptake; as e.g. Cairney (2016) remarks, this focus on barriers tends to overlook the normal workings of policy processes (Oliver, Lorenc, and Innvær 2014, 4). As can be seen from the results above, research frequently describes single elements of the process (dissemination, sources of evidence, knowledge transfer) rather than the entire process (p. 5). The literature consistently finds that the main factors are access to relevant and clear information and good relationships between researchers and policymakers (p. 5).

Methodically, the studies we found rely predominantly on surveys and interviews to gauge actors' perceptions instead of using e.g. participant observation to understand how evidence is being used by policymakers. In terms of authorship, policymakers are rarely involved in writing these studies. Emphasis is given to researchers' own views of research utilization (Oliver, Lorenc, and Innvær 2014, 5). Findings must therefore be taken with a grain of salt, as they frequently pertain to the perspective of one of the groups involved (i.e. from the perspective of researchers, policymakers do not understand academia well enough; from the perspective of policymakers, researchers lack understanding of the policy process).

As Cairney (2016) and others (e.g. Blewden, Carroll, and Witten 2010) repeat, policy theories could provide a more sophisticated account of policy processes to understand the seeming emergence of a gap between scientific evidence, the identification of relevant policy problems, and adequate policy responses.

Another big issue with this literature is that a large part of the studies on evidence-base policy making comes from the UK and Australia, while policy theories were for the most part developed in the US context (Cairney 2016, 10). The literature on knowledge transfer operates on an a priori separation between researchers, policy makers, and practitioners (Bekker et al. 2010). While these domains are certainly important, much work in STS (Science and Technology Studies) has shown that their boundaries are much more fluid than is commonly assumed. In fact, some (Gieryn 1999; Jasanoff 2005) argue that the boundaries between domains and groups are the outcome of processes of negotiation, which makes efforts to treat communication between scientists and policymakers as an independent variable ("knowledge transfer"; "knowledge translation" etc.) futile.

2.4 Normative Dimensions of the Evidence-Policy-Gap

2.4.1 Evidence for an Evidence-Policy-Gap

Gaps between research and policy making have been attributed to organizational factors that influence decision-making, cultural differences in terms of goals, values, and perspectives, technical challenges and insufficient communication (both in terms of content and in terms of channels). The upshot of these findings is that for research to be effective in policy making in the first place, it needs to be communicated effectively. Communication is often (e.g. Dodson, Geary, and Brownson 2015) invoked as a domain to be improved on the part of researchers, along with other interpersonal aspects of knowledge transfer such as maintaining credibility (reputation) (e.g. Haynes et al. 2012). In the literature, concepts such as co-production have recently begun to replace linear models of knowledge transfer (Ellen et al. 2014b: 5). Researchers who want their expertise given due consideration are advised to develop relationships across the policy community and to strategically use mass media; policymakers should look for alternative sources of information to identify

researchers (knowledge brokers, overlooked universities, NGOs) and to obtain a spectrum of advice (e.g. Haynes et al. 2012). In summary, this strand of research finds that lack of resources on the part of scientists are the most frequent barriers to promote evidence-based policy advice, as well as low policy relevance of research and lack of strategic thinking (i.e. the "two cultures model") (Cairney, Oliver, and Wellstead 2016, 400). A large proportion of the evidence-based policy literature uncritically assumes

- that an evidence-policy gap exists (Ellen, Léon, et al. 2014) and that "the gap needs bridging" (Rajić, Young, and McEwen 2013) – i.e. knowledge and practice are two different worlds (Ellen, Léon, et al. 2014)
- that policy is usually not based on data – here there is a surprising lack of evidence on how much evidence policymakers use which has been interpreted as evidence of absence; policymakers use other types of information which might be more relevant and timelier besides research evidence (Ellen, Léon, et al. 2014, 6) and that
- greater use of evidence will produce better outcomes, an assumption that remains untested empirically; at best, studies refer to process-related improvement (e.g. in terms of transparency) (ibid. 6)

2.4.2 Prospects for Closing the Evidence-Policy-Gap

To a considerable degree, then, the overall normative stance of these discussions ("How to bridge the gap") has side-lined empirical description of how policy processes work (Ellen, Léon, et al. 2014). Therefore, advice on how to make an impact on the policy process as a researcher is a powerful motive in the literature on the evidence-policy gap. Researchers wishing to influence policy are frequently advised to develop relationships across the policy community and to strategically use mass media (e.g. Haynes et al. 2012; 2011). It is desirable, at least from the perspective of researchers who wish to influence policy making, that policymakers look for alternative sources of information to identify researchers (knowledge brokers, overlooked universities, NGOs) and to obtain a spectrum of advice (Haynes et al. 2012). Solutions proposed to "bridge the gap" frequently involve encouragement of researchers and policy makers to collaborate, to make use of knowledge brokers (intermediary institutions), to broaden their definitions of research as well as the starting point for knowledge transfer (Choi et al. 2005), to expand the accountability horizon, and to acknowledge the complexity of policy making (Choi et al. 2005; Cairney, Oliver, and Wellstead 2016).

Much of this sort of advice is based on the conviction that the identified gaps in knowledge transfer are unlikely to improve organically (e.g. Gollust, Seymour, Pany, Goss, et al. 2017). Rather, improvement requires training to inform researchers about the spectrum of ways in which research can influence policy – from prioritizing issues to identifying issues that can be framed as policy problems. If we follow this line of thought, ultimately it falls upon research institutions to take a more active role in translation and reducing barriers for researchers and assistance in forming relationships with policy makers (Gollust, Seymour, Pany, Goss, et al. 2017), but also to consider policy impact and public communication of research in promotion/tenure criteria (Gollust, Seymour, Pany, Goss, et al. 2017). Within the policy making process, researchers' critical perspective and credibility can only fully develop in an environment that facilitates dialogue and enables researchers to acquire in-depth knowledge of the policy process (Elliott and Popay 2000).

Researchers wishing to improve the impact they are making are advised to adopt corresponding research approaches connecting policy makers, researchers, and intermediaries (Gollust, Seymour, Pany, Goss, et al. 2017). Funders should strengthen dissemination requirements in their tenders with respect to policy impact. In general, this line of research concludes that more research is needed to identify processes for promoting stronger linkages between researchers and policy makers (Gollust, Seymour, Pany, Goss, et al. 2017).

Cairney et al. (2016) make the case that while evidence helps to reduce uncertainty, policymakers rely on beliefs and emotions to reduce ambiguity by choosing a certain problem interpretation. Understanding the evidence-policy gap requires understanding the difference between empirical uncertainty and policy ambiguity (p. 399). Most empirical work, they argue, focuses on solutions to reduce uncertainty (Cairney, Oliver, and Wellstead 2016, 400). However, policymakers employ two shortcuts: rational shortcuts which include the formulation of clear goals and the prioritization of certain information, and irrational shortcuts including beliefs, gut feelings, and the like (p. 399). Most research on the evidence-policy gap focuses on the problem of uncertainty and responds with improving information supply and accessibility. Reducing ambiguity, on the other hand, involves establishing a frame for policy problems. There is thus no straightforward path from reducing uncertainty to reducing ambiguity, as these relate to two different cognitive domains. Policy making is a long-term, multilevel process involving networks of policymakers, paradigms, norms and (sometimes) quick succession of priorities (p. 400). Focussing on singular government decisions ignores the temporal and social dimensions of the policy process.

The upshot of the above discussion is that while there is a substantial body of literature (and empirical evidence) on the existence of an evidence-policy gap in health policy making, this research is to a large extent based on lay theories of the policy process, a deficit which extends to the sort of recommendations this body of work has produced. For the public health community, these recommendations can be summarized as

- Improve communication (Merlo et al. 2015)
- Improve clarity of writing
- Improve findability and accessibility of (certain kinds of) results (such as statistical or economic data) (Dodson, Geary, and Brownson 2015)
- Secure your own credibility and reputation (if you're a researcher) and
- Attempt to identify and contact the most relevant researchers

Cairney et al. (Cairney, Oliver, and Wellstead 2016) argue that solutions to the evidence-policy gap need to consider both the need for evidence as well as the need to reduce ambiguity on the part of policymakers, thus acknowledging the differences in constraints faced by policymakers as opposed to researchers. Advocates of scientific information who want to influence policy processes should thus engage in a process of persuasion, e.g. combining evidence with simple stories (p. 401) to exploit policymakers' emotional biases (Cairney, Oliver, and Wellstead 2016, 399). Policy theory suggests focussing on the links between evidence, persuasion, and framing within the wider multilevel context (p. 400), e.g. to highlight one problem frame (e.g. as a technical problem). This suggests that researchers should interpret evidence through the lens of policymakers' pre-existing beliefs (p. 401). Meaningful policy influence involves learning the rules of the game and the formation of long-term alliances, not a one-off dissemination of knowledge (p. 401).

The existing literature is therefore correct in promoting networks and mutual appreciation between scientists and policymakers. Incentives to increase engagement might be a way to achieve this (e.g. in promotion criteria). Knowledge brokers can be helpful in the sense that it enables policymakers to know who to ask (p. 401). The discussions on academic impact are unhelpful as they, too, promote a unilinear picture of engagement with policymakers (p. 401). Both the depiction of researchers and of policymakers in the literature discussed above comes very close to a deficit model of mutual understanding: In a nutshell, policymakers are depicted as ignorant of the research literature and as easily distracted, while researchers are depicted as having insufficient understanding of how policy processes work.

2.5 Models of Research Uptake in Policy making

2.5.1 The Assumption of Two Cultures

As we have seen, the role of researchers in policy making is often conceptualized as a linear process where the best available evidence ultimately or ideally begets the best possible policy, were it not for certain barriers stemming from characteristics of policymakers, researchers, and/or the relationship between the two (Löblová 2018). The research question is frequently formulated as: Can scientists and end users (e.g. policy makers) work together? Many have pointed out, however, that linear models of research uptake such as the two communities-model are empirically inadequate (e.g. Smits and Denis 2014; Cairney 2016). A substantial proportion of the literature on the evidence-policy gap concludes that researchers and policymakers differ substantially in their goals, values, attitudes towards information, languages, perceptions of time, and career paths (e.g. Choi et al. 2005). If correct, this entails that researchers need to balance conflicting roles and identities when engaging with policymakers in policy contexts. These have been described with reference to Mertonian disinterestedness (Merton 1973) as an attitude associated with argumentative rigour and rationality which comes with the associated risk of policy irrelevance (Haynes et al. 2011).

For researchers to be able to influence policy, the ability to understand these different worlds is key. Haynes and colleagues (2011) found that researchers engage in a variety of strategies to disseminate research, from targeted research design to multilateral collaborations to tactical use of the media, and further, that "traditional" scientists and "contemporary" (socially engaged, collaborative) scientists are guided by a different ethos. Accordingly, the study also found that where researchers were successful in influencing policy, this influence worked via personal communication, not via publishing research papers. An alternative strategy employed by researchers wishing to influence policy making was to target lower impact journals aimed at practitioners (Haynes et al. 2011).

Gollust et al. (Gollust, Seymour, Pany, Goss, et al. 2017) describe how researchers and policymakers reside in two different worlds. According to their study, the two groups differ fundamentally, even in how they interpret the concept of research (though both groups consider the instrumental value of research in the policy making process). They point out, however, that both researchers and policy makers face essentially the same barriers to research translation. Mutual distrust is a recurring issue – policy makers questioned the credibility of research(ers), and researchers questioned policy makers' authentic desire to use evidence in decision making (i.e., researchers feared their expertise was being used merely to provide legitimacy, not to

develop policies in the first place). The study also found varying perspectives on the value of research in policy making among the two groups, wherein negative aspects of the policy process correspond with a high level of distrust for the other group. Both groups expressed a mismatch between policy makers' needs and what research can deliver. Therefore, policy makers tend to rely on reputation and personal networks to recruit expert advisors.

For researchers, competing demands on their time (tenure/promotion criteria) hinders effective communication with policy makers; conversely, time constraints also keep policy makers from engaging with research ("deluge of information"). There is then a mutual lack of understanding (of the research process resp. the policy process – "telling the truth" is not enough to make an impact). Policymakers value research in the policy process, nevertheless. Evidence was considered a part of politics by most policy makers; while policy makers worry about bias in research, researchers qualify the non-research-factors in the policy process as biased (Gollust, Seymour, Pany, Goss, et al. 2017).

Olesk et al. found that "[w]hile evidence-based decision making exists in the Estonian public administration, it remains under-developed and under-utilised" (2019, 3). When looking into strategies employed by researchers to influence policy, these are always value-laden and politicized and therefore cannot be understood solely as evidence-based (Cairney and Oliver 2017). Because researchers and policymakers belong to different communities (Löblová 2018), the role of the intermediary has gained importance (Gagnon 2019). Intermediaries are sometimes known as knowledge brokers whose role is to facilitate knowledge transfer (Olesk, Kaal, and Toom 2019, 3). In the context of Open Science, the knowledge transfer process is usually modelled as a unidirectional process (Olesk, Kaal, and Toom 2019, 2), as the utilization of publicly available knowledge without involvement of the knowledge producers.

2.5.2 Functions of Evidence in Policy making

A large part of the empirical literature reviewed here implicitly assumes the "two cultures model", but, as Cairney et al. (2016) point out, the model turns on an – ultimately untenable – separation of two aspects of policy advice: reducing uncertainty versus reducing ambiguity. As we have seen, this literature

> "highlight[s] differences in academic and political "cultures": language and jargon, longer scientific timescales, low incentives to engage, differing perceptions of scientific knowledge, and the relative need for scientists to challenge evidence (to ensure it is robust) but for policy makers to generate an image of policy certainty and reconcile evidence with well-established beliefs. There is also a perception that policy makers rely on personal experience, ad hoc links with experts, people they know and trust, and simple decision-making techniques and stories rather than the state-of-the-art in scientific research and sophisticated modeling systems (Lomas and Brown 2009, 906)". (Cairney, Oliver, and Wellstead 2016, 400)

The problem implicit in the diagnosis of an evidence-policy gap is thus defined in terms of improving the evidence base, better communication of information, improved interaction with policymakers, better timing, and the use of knowledge brokers (Rose et al. 2019). If Cairney et al.'s (2016) analysis is correct, however, a deeper analysis of the way policy processes work is necessary to understand which aspects are amenable to influence. However, instead of attempting to understand policy processes, "researchers [in the field of

evidence-based policy making] have directed their attention at how to increase their own outputs, rather than on understanding the processes behind policy change" (Oliver, Lorenc, and Innvær 2014, 3).

Before reviewing the most prominent models of the role of scientific expertise in policy making, we summarize the literature with respect to the reasons why scientific evidence would be used in policy making in the first place. The literature broadly distinguishes two types of motivation for the use of scientific evidence in policy making:

- Reducing ambiguity and increasing clarity of decisions (Cairney and Oliver 2017)
- Reducing uncertainty of decisions (Cairney and Oliver 2017; Cairney, Oliver, and Wellstead 2016)

As Cairney et al. (2016) point out, however, a large proportion of the empirical work has been focussing on a third aspect, and that concerns the question how the flow of information between decision makers and researchers might be improved. An equally important aspect concerns reducing ambiguity of information, however, which is implicated in processes of policy making through forming coalitions, gut feelings, beliefs and ideological allegiances (ibid. 399). Conflict is conducive to decision makers seeking out expert-advice and -evidence (Lundin et al. 2014).

Research needs to be policy-relevant in the first place in order to be considered by policymakers (e.g. Rose et al. 2019; Gollust, Seymour, Pany, Goss, et al. 2017), but this is only a necessary (and by no means a sufficient) condition. Boswell (2008; 2009) identifies three functions of expert knowledge in policy-making (Holm and Ploug 2015, 15): Expert knowledge works (1) as an instrument to achieve a (given) aim (instrumental), (2) as a means to confer epistemic authority and thereby legitimacy (symbolic function), and (3) as a means to substantiate already formed policy preferences (symbolic function). To illustrate, Christensen (2018, 293) points out that at least since the end of World War II, particular interest of policymakers accrues to economics, which has begun to bestow more legitimacy in policy advice than other forms of knowledge. This has been variously attributed to economics' (supposed) role in ensuring prosperity, and in economic knowledge bestowing an aura of rationality on decision-making (instrumental versus symbolic function) (ibid.).

2.5.3 Models of Knowledge Transfer

Blewden et al. (2010) distinguish three broad types of knowledge transfer (p. 14):

- conceptual (i.e. research is used to clarify and reframe thinking, challenge assumptions, or provide new understanding)
- instrumental (i.e. research is used to directly influence policy decisions, predicated on the assumption of a rational decision-making process), and
- the symbolic model (i.e. research is used to provide legitimacy and support for existing programmes and positions)

It must be stressed that these three dimensions of research utilization are complementary. Mitton et al. (2007: 729) note that the purpose of Knowledge Transfer and Exchange is to increase the likelihood of

evidence being used in policy decisions. Knowledge Transfer and Exchange is described as an interactive process involving the interchange of knowledge between research users and research producers. However, it is unclear which Knowledge Transfer strategies are fit for what purpose (Lavis et al. 2003). In 2007, Mitton and colleagues were still able to state that no summary of the current evidence on Knowledge Transfer and Exchange had been produced (Mitton et al. 2007, 729). To further complicate matters, the different literatures on the topic use different terminologies (Mitton et al. 2007: 729) despite a more general culture of accountability, cf. (Mitton et al. 2007; Davies, Nutley, and Smith 2009). Many Knowledge Transfer typologies follow a classic paper by Carol Weiss published in Public Administration Review (1979) where she introduced seven models (i.e. ideal types) of knowledge transfer:

- the knowledge-driven model (Weiss 1979, 427), which assumes a straightforward sequence of events from basic research to applied research to development to application
- the problem-solving model (the most common approach according to Weiss; Olesk, Kaal, and Toom 2019, 2); the problem-solving model often leads to disillusionment since research rarely provides unambiguous answers to policy problems
- the political model of knowledge transfer (Weiss 1979, 429) takes note of the fact that policy decisions are frequently predetermined by the constellation of interests surrounding a given issue
- the tactical model refers to instances where the mere fact that research is (allegedly) being done on a subject is used to suggest action on the part of policymakers and to deflect criticism (Weiss 1979)
- the interactive model, wherein various actors reach a common decision after mutual deliberation (a large proportion of recent literature has followed Weiss in conceding that successful knowledge transfer requires an interactive element, e.g. Lavis et al. 2003)
- the enlightenment model, which refers to the gradual permeation of policy processes by the concepts developed in research (Weiss 1979, 429)
- the intellectual enterprise model which assumes that research utilization is part of a more general thrust towards a knowledge society (Weiss 1979, 430): "Like policy, social science research responds to the currents of thought, the fads and fancies of the period" (Weiss 1979, 430)

Building on Weiss (1979), Mitton et al. (Mitton et al. 2007, 741) suggest that these seven models be condensed to research results being used in one of three ways: instrumental (problem-solving model), conceptual (enlightenment model), or symbolic (political/tactical model). Before Mitton et al. (2007), Lavis and colleagues (2003) proposed three categories of knowledge transfer activities which they labelled as a) producer push (research disseminate results in the hopes that they will be used), b) user pull (users express or create a demand for findings), and c) linkage and exchange (development of networks between researchers and policymakers; this has been discussed under the heading "Interaction" above) (Sebba 2013, 396). Building on work by Lavis (2003), Ellen et al. (2014, 2) outline a framework to assist in transferring knowledge to policy action. Seven aspects are identified as conducive to knowledge transfer:

- establishing an (organizational, institutional) climate for research reuse
- research production (i.e. researcher activities to produce research)
- efforts by researchers (or knowledge brokers) to encourage research use ("push efforts")
- facilitating pull efforts (i.e. infrastructures for knowledge dissemination)
- efforts by decision-makers to get hold of research results ("pull efforts")

- exchange efforts that facilitate relationships between researchers and knowledge users, and
- evaluation efforts

It is not predetermined where OS fits in this analytical framework. Concrete practices may draw on more than just one of the models or elements of it. As a general observation it can be noted that large parts of the reviewed literature are not explicit regarding their understanding of the knowledge-transfer model they draw on. The ways in which knowledge transfer should happen is often taken for granted and therefore remains obscure.

2.6 Research Gaps and the Potential for Open Science

2.6.1 Benefits of Open Science

There are few direct references to Open Science (OS) in the literature reviewed in this report. While this may have to do with the fact that the discussions around evidence-based policy making predate the OS movement by a few decades, the literature still presents many points of departure for studying the potential for OS that merit further investigation. For OS to have a (positive) impact on knowledge transfer and research utilization by policymakers, (at least) two conditions need to be fulfilled: (1) at least some countries need to have adopted OS principles, or in any case started a debate on OS, and (2) there needs to be some established role in charge of evidence-informed policy-making (Olesk, Kaal, and Toom 2019). The second condition is easier to meet, since many countries have started to create such knowledge brokers (Lavis et al. 2003). As has been shown in the preceding sections, the evidence-policy gap is a common thread of research on knowledge transfer resp. knowledge exchange (e.g. Curran et al. 2011). Curran and colleagues define the aim of Knowledge Transfer (KT) research as follows: to "develop a generalizable empirical and theoretical basis to optimize KT activities" (Curran et al. 2011, 175). This is instructive for the present discussion, as it highlights the practical impetus (design and improvement) of the entire field of knowledge transfer research. The gaps in the KT research landscape identified in the paper provide an excellent starting point for discussing potential benefits of OS, e.g. starting with the so-called Proteus Effect (Ioannidis 2005). This is extremely relevant to the present context since it directly relates to OS, as does a lack of research into knowledge retrieval and knowledge management infrastructure. In order to better assess whether OS lives up to its promise, we start by summarizing the benefits of OS in terms of knowledge transfer as envisioned by OS advocates. The term "Open Science" refers to a variety of practices, ranging from making available (all) research outputs (e.g. data, notebooks, publications, software) to increasing openness and transparency throughout the entire research process including research evaluation (e.g. through Open Peer Review).

2.6.2 Research Gaps and the Prospects for Open Science

Following Oliver et al.'s (2014) and Cairney's (2016) insights, the prospects for OS to make a positive impact on the evidence-policy gap should be judged against the backdrop of policy theory. The gaps in Knowledge Transfer (KT) research identified in Curran et al.'s (2011) paper are as follows:

- Research on the proteus effect (optimism upon initial publication of novel findings – half of published findings are false)

- Identification of knowledge to action gaps (measurement of gap, reviews, quality indicators); knowledge syntheses (contextualization and integration of case studies within the larger body of knowledge, e.g. the Cochrane collaboration for systematic reviews)
- Knowledge retrieval & management (databases, search strategies & methods, data & reference management) (p. 176)
- Development of methods to assess barriers and facilitators to KT (understanding the cognitive and social factors that impact decision making; design of effective intervention strategies, induce behavioural change among patients, practitioners, and policymakers) (p. 176)
- Development of methods for optimization of KT strategies (evidence-based intervention development) (p. 176)
- Evaluation of KT strategies (based on research question, setting & feasibility of the intervention) (p. 177)
- Development of KT research methods (to translate research into practice, to develop consensus on KT methodology and practice) (p. 177)
- Development of KT theory (explanatory or predictive theory is needed to design and test interventions; 28 different KT models in the literature with 5 common components: problem identification, knowledge development, context analysis, KT interventions, research utilization; challenge: to choose the right theory for a given intervention) (p. 177)

2.6.3 Reservoir Knowledge and the Role of Systematic Reviews

Grimshaw and colleagues (2012) point out that individual studies are only appropriate as a means for knowledge transfer when the target group are researchers. While potentially relevant, individual studies rarely provide sufficient evidence for policymakers in and of themselves and may in fact be biased (cf. Ioannidis et al.'s work on the Proteus effect that effect sizes tend to diminish with further studies). Here, replication studies, systematic reviews and syntheses are needed (Grimshaw et al. 2012: 2) to contextualize results. Even then, translators are needed to identify key messages (Grimshaw et al. 2012, 3). Curran et al. (2011) also find a lack of knowledge syntheses contextualizing and integrating case studies within the larger body of knowledge. This aspect of the problem might be addressed in optimizing the role of systematic reviews. Some (e.g. Gold 2009) are ambivalent with respect to OS: While advocating public infrastructures (repositories) on the one hand, Gold concedes (in her work on "Pathways to the Use of Health Services Research in Policy") that policy impact can also be generated via high-impact publications. "Blockbuster findings" may generate immediate impact, e.g. via press coverage of publications in high-impact journals (even though the findings might not always match current policy interest) (Gold 2009, 1125). However, she concedes that gradual accumulation and diffusion of knowledge is more common which then often leads to findings becoming common knowledge (a process lacking quality control, however). Gold (2009, 1126) points out that this process may be impeded when research results are not published, archived and appropriately indexed. Here, formal synthesis of existing evidence would be an option but is usually badly supported (Gold 2009, 1126). The author stresses that knowledge brokers also depend on access to "reservoir knowledge" (Hanney et al. 2003), i.e. an accessible pool of established scientific findings, to fulfil their aims. Providing access to this pool of knowledge is clearly an aspect where OS is desirable, as it could help to address the issues of untimeliness and frequent irrelevance of research to given policy problems. The role of systematic reviews in knowledge transfer has been discussed above and cannot be overestimated in this regard.

2.6.4 Missing Infrastructure, Tools, and Databases

A more prominent theme in the literature reviewed here pertains to (a lack of) infrastructure for knowledge exchange (Bekker et al. 2010; Curran et al. 2011; Ellen et al. 2011; Ellen, Léon, et al. 2014; Lavis et al. 2003; Grimshaw et al. 2012; Hoeijmakers, Harting, and Jansen 2013). Generally, the studies reviewed here concede that improved infrastructure is an important aspect of knowledge exchange, but not a decisive one (Gold 2009). Despite her overall ambivalent attitude towards other aspects of Open Science, Gold (2009, 1131) finds that infrastructures for data and literature mining and synthesis can help improve research uptake. She mentions publicly available (open) repositories and a form of preprints as ways to overcome publication delay; recall that the untimeliness and irrelevance of research results to policymakers' agendas was one of the most frequently identified barriers to research uptake. Ellen and colleagues (Ellen, Léon, et al. 2014) found a preference for technical support structures of the kind that are typically favoured in Open Science, e.g. repositories for data and publications, with adequate search functions. The article is six years old, however. As the transformation towards Open Science is well underway now, this seems to be a moot point. In a study of regional health authorities' support structures for knowledge exchange, Ellen et al. (Ellen, Léon, et al. 2014) found that respondents desire better documentation and reporting tools. Tools for communication and decision support were most frequently mentioned as facilitating Knowledge Transfer and Exchange, as well as the implementation of technical knowledge infrastructures to support research use and ensure access to research evidence – e.g. centralized repositories for sharing research, access to journals and databases, and appropriate wireless access in hospitals. Clearly, these are areas where there is a strong overlap to the OS agenda.

In general, building bridges between results is paramount to avoiding information overload (this can be done by existing intermediaries, however) (Gold 2009, 1131). Credibility and trustworthiness are important additional aspects of using research infrastructures in knowledge exchange. Grimshaw and colleagues (2012) find that messenger credibility is crucial, but the role is time-consuming and skill-intensive (p. 3). Here, adequate infrastructures could help to address the specific needs of the healthcare system's stakeholders. The study mentions two examples from Canada: Rx for Change, a publicly accessible online database of syntheses for the global evidence from systematic reviews (p. 4), and Health Systems Evidence, a database for policymakers (repository for syntheses) (p. 4). Hoeijmakers and colleagues (2013) point out, however, that in addition to infrastructure, cross-domain knowledge transfer depends on subsequent cultural change, e.g. applying a deliberative approach to policy making (stakeholder involvement, dialogues).

3 Open Science: Reframing the Science-Society Relationship

3.1 Introduction

The relationship between scientific knowledge and the public domain has been an issue at least since the 17th century, especially for enlightenment philosophy. At the peak of the Enlightenment, Immanuel Kant defined "Aufklärung" as the public use of reason (Kant 1994). Ever since, scientific knowledge and the public domain have remained closely related to one another. In this part of the deliverable, we aim to uncover the various forms the science and society relationship has taken. How has this relationship been rethought, reorganised, and reshaped over time? In light of historical analysis, we understand that Open Science (OS) has not discovered the science and society relationship, but rather has to be conceived as re-articulating an issue that has a long history. For this reason, the evident question to ask is whether OS is merely old wine in new bottles or whether it has something new to offer. If the answer is affirmative, the next step would be to inquire into what exactly it is that OS brings to the table in terms of reframing the science and society relationship.

Reframing is a common practice in the scientific domain. There is nothing unusual about issues, questions or problems being addressed in novel ways and investigated with new methods or terminology (Kuhn 1962). In the social sciences especially, it is common for consecutive generations of researchers to ask the same questions anew, but to come up with varying, and occasionally competing, answers.

In recent years, the idea of Responsible Research and Innovation (RRI) has gained considerable academic traction and political attention as a novel form of addressing the science-and-society relationship (Rip 2014). RRI combines a wide variety of perspectives, each with its own history and unique relationship to (some of) the other perspectives. Open Access (OA) is now conceived to be an important element of RRI (in fact, OA has been declared one of the six pillars of RRI, alongside gender, ethics, governance, public engagement, and science education) (European Commission and Directorate-General for Research and Innovation 2012, 3–4).

There is considerable overlap between the six pillars, which makes it difficult to keep them apart and draw a sharp demarcation line between them. It should be noted that none of these pillars or "policy agendas" is entirely new (https://www.rri-tools.eu/about-rri). The concerns these pillars address have been discussed under different names and perspectives for decades, including, among others, Technology Assessment (TA), ELSA, and Anticipatory Governance. The appearance of novelty with respect to RRI stems from its decidedly normative problem framing. Arie Rip calls it a form of "moral labour", since RRI frames the science and society relationship in terms of "responsibility" (Rip 2014). We will return to RRI later in this chapter to discuss its relationship with Open Science.

In what follows, we develop an account of the science and society relationship, beginning with the emergence of modern science in the 17th century. Inevitably, such an attempt will remain incomplete. Despite the obvious difficulties of describing historical developments over long time periods, our attempt can be justified

by the modesty of its goals. The (admittedly sketchy) historical account of the science and society relationship we developed here seeks to establish the following analytical points:

- Open Science advocates are not the first to address the science and society relationship
- The science and society relationship changed considerably over the past 400 years
- Discontinuity: The changing relationship of science and society does not develop by way of continuous progression – rather, its development as a sequence of discontinuities and historical upheaval
- Plurality: The science and society relationship is not homogeneous – multiple relationships exist side by side (or in competition with each other)
- Self-reference: Negotiating the "appropriate" form of the science and society relationship is an integral part of the relationship

3.2 Academic Interest in the Science-Society Relationship

Research on interest in the science-society relationship can be traced back to the 1970s (David 2005, 10). Even though the relationship is much older, it caught the attention of the social sciences fairly recently. Some of the literature on the science and society relationship has produced valuable insight into the history of science and its relationship with the public (Shapin and Shaffer 1985). Here, we limit our review of this literature to a few milestones. In this way we hope to demonstrate that the relationship has indeed existed much longer before being accorded a more central position within social scientists' research interests. To begin with, we summarize key aspects of the history of modern science as the first chapter of the science and society relationship to inform subsequent inquiries into the relationship between science and society.

3.2.1 The Science and Society Relationship: early boundary work

When science took its modern shape and developed its first institutional arrangements in the form of the Royal Society in the UK and the Académie des sciences in France, the immediate concern was whether the practice of scientific truth making would influence the social and political order. Arie Rip notes that "a long-term 'settlement' between science and society started in the late 17th century (in the 1660s in France and Britain, to be more precise), one indication being how the UK Royal Society was established with an implicit political charter: you can do science if you don't interfere in society" (Rip 2014, 4).

It is interesting to observe that the founders of the Royal Society declared that they would not "meddle" with "Grammar, Rhetorick, or Logick".[5] These three canonical disciplines formed the basis of higher education at the time. The apparent distance between science and the practice of university education is instructive, since it reveals the role of the university in reproducing social elites whose job it was to maintain the social order and established power relations. In this way, a "macro-protected space for science was created" (Rip 2011) and a "social contract between (emerging) science and society was established" (Rip 2009, 4).

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[5] At the same time the founders declared that they would not interfere with "Divinity, Metaphysics, Moralls". In other words, the authority of theologians over these domains would not be challenged (Rip 2014).

Having ensured that the pursuit of scientific truth making would not interfere with politics, scientists in turn began to claim autonomy for their affairs and "[lead] scientists to become active in the wider world, as an embodied force of progress" (Rip 2009, 4). In this way, science was not a threat to established power relations.

3.2.2 Knowledge making: the public as witness

Observing the science and society relationship (especially in the 20th century) foregrounds the deliberation of environmental, social and political aspects of scientific practices. To a certain extent, framing the issue in this way advances the impression that scientific truth as such is unproblematic. Obviously, this was never the case, begging the question whether scientific debates are first and foremost the concern of insiders, i.e. members of the scientific community (Collins 1985; Gilbert and Mulkay 1984), or whether the business of truth making relates to the public domain (and if so, in what way)?

Historians of science remind us that the first scientists yet had to establish their authority over truth making (Shapin and Shaffer 1985). This process is intimately tied to the invention of the scientific experiment. The experimental method was established in the 17th century. In their well-known book "Leviathan and the Air-Pump" Steven Shapin and Simon Schaffer (1985) profess to reconstruct the 17th century debate between Thomas Hobbes and Robert Boyle. Boyle is widely regarded as the originator of the experimental method in science (if we ignore Galileo Galilei for the sake of argument and do not mention Otto von Guericke's air-pump experiments, performed a decade before Boyle's[6]). Crucially, the role of the public as witness developed into a key element of Boyle's method of determining "matters of fact" by scientific means. Boyle regarded knowledge making as a public undertaking and therefore suggested that experiments need witnesses.[7] This criterion of public testimony was the main difference to alchemy (non-science) which was regarded by its critics to be a secretive and isolated practice.[8]

Boyle's main opponent Thomas Hobbes did not object to truth-making being a public affair. However, he disagreed with Boyle's ideas regarding the composition of an appropriate public (Shapin and Shaffer 1985,

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[6] "Boyle knew about Otto von Guericke's work, and intended to improve upon his device, described by Caspar Schott in his *mechanica hydraulicopneumatica* of 1657." (Shapin and Shaffer 1985, 26). "This was the book that prompted Boyle's decision to begin the construction of an air-pump allegedly superior to Guericke's device shown here." (Shapin and Shaffer 1985, 334).

[7] Shapin and Shaffer do not claim that Boyle was the first to call for public testimony, but he was important in establishing just that as a scientific standard. "It is not novel to notice that the constitution of experimental knowledge was to be a public process." (ibid. 39, see also 217). They emphasis this point: "In the case of Boyle's experimental philosophy, some of the most important conventions concerned the means by which the matter of fact was to be generated. A fact is a constitutively social category: it is an item of public knowledge." (ibid. p. 225)

[8] The contrast was, on the one hand, with the private work of the alchemists, and, on the other, with the individual dictates of the systematical philosopher." (ibid 78). In fact, this was the centre of the debate as Shapin and Shaffer note: "What little we do know about English experimental spaces in the middle part of the seventeenth century indicates that their status as private or public was intensely debated." (ibid.: 335)

113, 334). In Boyle's case, public witnesses had to be respectable individuals[9], which amounted to them being members of the Royal Society, including (…) its royal founder his majesty himself" (Shapin and Shaffer 1985, 218, 31). In other words, Boyle envisioned a qualified public. Hobbes was not convinced of such a restricted conception of the public.[10] Rather than mere witnessing, the crucial point for Hobbes was that there was a public *discourse* in which everybody could take part.

> "Hobbes's philosophy also had to be public because its purpose was the establishment of public peace and because it commenced with social acts of agreement: settling the meanings and proper uses of words. Its public was not a witnessing and believing public, but an assenting and professing public: not a public of eyes and hands, but one of minds and tongues." (Shapin and Shaffer 1985, 224).

In hindsight, we know that Boyle prevailed over Hobbes and the experimental method became central for scientific truth-making. With the establishment of the laboratory as the privileged space for truth-making, bearing witness became a fairly restricted practice and was essentially limited to members of the scientific community.[11] In other words, scientific truth-making was simultaneously defined as public and restricted to a small group of qualified experts:

> "The public space insisted upon by experimental philosophers was a space for collective witnessing. We have shown the importance of witnessing for the constitution of the matter of fact. Witnessing was regarded as effective if two general conditions could be satisfied: first, the witnessing experience had to be made accessible; second, witnesses had to be reliable and their testimony had to be creditable. The first condition worked to open up experimental space, while the second acted to restrict entry. What in fact resulted was, so to speak, a public space with restricted access." (Shapin and Shaffer 1985, 336).

Even though Hobbes' position became marginalised and almost forgotten (Shapin and Shaffer 1985), his epistemological stance continues to be influential. More than a century later for instance, Immanuel Kant drew on the idea that the public nature of science was to be the participation in a public discourse, which in his words was the practice of "pure reason" (Kant 1994).

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[9] „The credibility of witnesses followed the taken-for-granted conventions of that setting for assessing individuals' reliability and trustworthiness: Oxford professors were accounted more reliable witnesses than Oxfordshire peasants. The natural philosopher had no option but to rely for a substantial part of his knowledge on the testimony of witnesses; and, in assessing that testimony, he (no less than judge or jury) had to determine their credibility." (ibid. 58; see also 78, 327)

[10] „The space where these machines worked—the nascent laboratory—was to be a public space, but a restricted public space, as critics like Hobbes were soon to point out. If one wanted to produce authenticated experimental knowledge— matters of fact—one had to come to this space and to work in it with others." (ibid. 39)

[11] „In Boyle's programme there was to be a special space in which experimental natural philosophy was done, in which experiments were performed and witnessed. This was the nascent laboratory." (ibid. 334).

3.2.3 The Institutionalisation of Science

It is difficult to do justice to the development of science since the emergence of its modern form in the 17th century in what short space we have. The account will therefore be restricted to some conspicuous transformations.

Three developments of the 18th and 19th centuries are especially important: a) universities developed into research institutions[12] (alongside the Academies), b) research became a profession and c) engineering became academic. However, the image of the Ivory Tower is quite misleading here. Stephen Shapin recounts how the cultural trope of the Ivory Tower has changed over time and how it was attached to scientific practices only after the Second World War to describe an imaginary past (Shapin 2012, 25).[13] The utility of scientific knowledge had in fact become apparent much earlier.[14] So powerful were scientific achievements that the idea of "progress" became a cultural experience of the 18th and especially 19th centuries (Passmore 1975, 218). In its wake, even mathematics became "applied". With the development of statistics in the 19th century – 'social mathematics' as it was then called – mathematics became relevant to government (hence the name – state-istics) (Höflechner 2008, 108).

As science became increasingly relevant for governments in the 19th century, the state developed an interest in exerting control over universities. Importantly, as Foucault has shown, the form of governance underwent considerable transformation during that period (Foucault 2010). The "will to knowledge" characteristic of the sciences was in fact a will to govern the population through acquiring knowledge about it (Foucault 1998), a process which entails the discovery of the population as an object of study. The novel relationship between knowledge and power necessitated clarification of the boundaries between the state and the university. Unlike earlier (e.g. medieval) forms of academia, the research university depended increasingly on state funding.[15] This is especially true for newly founded institutions. The Humboldt University in Berlin is a prime case for this type of formation. Founded in 1809, Wilhelm von Humboldt designed its organisation and defined its relationship to the Prussian state. Although the role of the state was to provide financial aid, Humboldt insisted that it had to refrain from interfering into scientific matters for which scientists claimed autonomy. The Humboldt University became a model for many subsequent foundations. Importantly throughout Europe, many existing Universities conducted reforms following the Humboldt model.

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[12] Initially they had not contributed to scientific research and only gradually started to do so (Höflechner 2008, 10, 93, 97).

[13] "It started as a religious figure, which it remained until nineteenth-century writers respecified it in an artistic context. Its subsequent mobilization to say something about what a university was and should be, and the conditions the university provided for the production of knowledge, largely happened during and after the Second World War, as did its relocation from comment on the imaginative arts to those practices which had the potential to produce materially useful goods – the sciences, engineering and the knowledges of the professional schools in particular." (Shapin 2012, 25)

[14] Höflechner dates this development in the 18th century (Höflechner 2008, 97).

[15] Older Universities enjoyed more independence, especially if they were financially independent due to having acquired capital over the centuries (Höflechner 2008, 97).

It is true that "autonomy" was a very prominent motive of science at the time. Yet, this does not mean that science was in fact disengaged or without practical utility.[16] Autonomy (self-governance) is not synonymous with Ivory Tower. Evidently, the social relevance of scientific knowledge was inspirational for thinkers such as Hegel, Comte, Marx and others who aspired to becoming the "Newton of history" (Passmore 1975).

The recognition of scientific knowledge as a relevant subject of education is perhaps another indication for its social significance. "The Mechanics Institute movement spread across Britain in the 1820s and 1830s and offered a training in science and technology to the skilled working classes." (Irwin 1995, 11). Despite its practical utility in engineering science, education was also seen as a cultural value and social participation (Blankertz 2011, 207). Labour movements across Europe were ambitious to educate the working classes about scientific advances. The time around the turn of the 19th to the 20th century was a time of considerable science popularisation.[17] Labour associations founded public libraries and adult education centres [Volkshochschulen][18] to ensure universal access to (scientific) education. Vienna stood out in the Habsburg Empire with its "Volkshochschulen" where academics taught the working classes scientific content in an egalitarian and democratic way in its "Fachgruppen" (Filla 2001, 11, 25). Teaching was based on active engagement of students and included laboratory experiments and small-scale research practices (Filla 2001, 72). Still, the middle classes remained sceptical about the idea of educating the working classes. Sceptics perceived universal education as a threat to their class interests (Blankertz 2011, 206). The boundary between science and society was redrawn again through claims of social relevance after the First World War (Rip 2009, 4). During this period, scientific knowledge was increasingly framed in economic terms and became an object of state governance.

3.2.4 Linear innovation: an economic framing

The idea that scientific knowledge contributes to economic prosperity is commonly associated with post World War Two policies. The famous Vannevar Bush manifesto (first published in 1945) is the classical reference for this framing of the science and society relationship (Bush 1960). Behind the promotion of scientific research and its endowment with public funding stands the assumption of a *causal* relationship between scientific knowledge and socioeconomic benefits. This assumption is also known as the "linear model of innovation"[19] (Godin 2016, 639). Again, Bush is commonly perceived as the author of this model.

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[16] Sheila Jasanoff makes a similar point and furthermore notes: "The notion that science exists as an autonomous form of life, constrained only by its truthfulness to nature, has permitted science to chart its own research trajectories, legitimate controversial policies, and authorize political institutions to undertake large technoscientific projects, from nuclear power to mapping and sequencing the human genome, that reach ever more consequentially into people's lives." (Jasanoff 2012, 17).

[17] Well into the 20th century, science was brought to the public in Britain. Irwin notes: "In the twentieth century, the need for a greater awareness of science became a major theme of the 'visible college' of scientists and writers who adopted a socialist perspective on scientific progress. (Werskey, G., The Visible College (London: Allen Lane 1978). As J.B.S. Haldane put it in the Preface to his 1939 book, Science and Everyday Life: "Without a much broader knowledge of science, democracy cannot be effective in an age when science affects all our lives continually." (Haldane, J.B.S., Science and Everyday Life (Harmondsworth: Pelican Books, 1939 – reprinted 1943) p.8.; cited after (Irwin 1995, 11).

[18] The Vienna Volkshochschulen were founded on 22. January 1887 (Filla 2001, 29).

[19] Godin explains: "The model postulates that innovation starts with basic research, then adds applied research and development, and ends with production and diffusion: Basic research → Applied research → Development →

However, Benoit Godin argues convincingly that Bush was not (Godin 2016).[20] Godin traces the linear model back to the early 20th century and shows that it was in fact a rhetorical construction of (U.S. American) industrialists and their (lobby) organisations such as the "National Research Council" (Godin 2016, 642). At the time, engineers and their representatives strived for social recognition of their achievements and sought for governmental support.[21] J. J. Carty, vice-president of American Telephone and Telegraph argued for instance: "The future of American business and commerce and industry is dependent upon the progress of science" (Carty, 1924, p. 1, cited after Godin 2016, 643). Clearly, Carty was convinced of the practical utility of scientific knowledge and the place he thought this knowledge was to be produced was the university[22] (Godin 2016, 643). Despite this early recognition of the crucial role of scientific knowledge for industry, it is important to note that industrial research was not separated from product development.[23] In fact, research and development were in the same departments and often carried out by the same people. Only later, the emerging linear model became operational and implemented into organizational structures of industrial companies and public administration.

Statistical accounts played an important role in the development of the linear model of innovation. "Statistics solidified a model in progress into one taken for granted—a social fact." (Godin 2016, 647). Statistics meant data collection and measuring. Here the state is the prime actor who carries out the necessary data collection and subsequent statistical analysis.[24] At first, no disaggregated data were available, but it was through data collection itself that categories were created, which eventually turned into stages of the innovation process

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(Production and) Diffusion" (Godin 2016, 639). The linear model is very influential, it is often used but also criticized. However, its origin is almost never properly cited. As Godin shows it is taken for granted (ibid. 2016, 640).

[20] Godin makes it clear that the linear model owes little to Bush. "It is rather, a theoretical construction of industrialists, consultants, and business schools, seconded by economists. The article also argues that the long survival of the model despite regular criticisms is because of statistics" (Godin 2016, 640–41; see also p. 645).

[21] Industrialists and their representatives would distinguish between basic and applied research. As Godin explains: "The dichotomy was a rhetorical resource used by scientists, engineers, and industrialists for defining, demarking, and controlling their profession (excluding amateurs), for financial support (scientists), for raising the status of a discipline (engineers), and for attracting scientists (industrialists)." (Godin 2016, 642). Their assertion of the importance of scientific knowledge drew on a much older distinction between pure and applied science, which goes back to the early days of science in the 17th century. Godin continues to explain that the term pure science "came into regular use at the end of the nineteenth century and usually was accompanied by the contrasting concept of applied research" (Godin 2016, 642).

[22] Godin notes: "But "where are the universities to obtain the money necessary for the carrying out of a grand scheme of scientific research? It should come from those generous and public-spirited men" [philanthropists and, much later, the State] and "from the industries" (pp. 14–15). This rationale is not very far from that offered by W. von Humboldt, founder of the modern university, in his memorandum of 1809 (von Humboldt 1809). Godin states that Vannevar Bush followed in this rhetoric in The Endless Frontier of 1945.

[23] Early researchers – including the well-known J.D. Bernal – stated that it was "difficult to distinguish between scientists and technicians in industrial service" (Bernal cited after Godin 2016, 646). "Both activities were carried out in the same department, and it was the same kind of people (engineers) that carried out both types of tasks (Wise 1980; Reich 1983)" (Godin 2016, 646). First traces of the distinction between several "stages through with research travels on its way toward adoption of results in industry" (Stevens 1941, 6-7)" can be attributed to R. Stevens (Godin 2016, 647).

[24] In the USA, the NSF did just that since the 1950s, although there was also scepticism about the utility of the taxonomy even by US government of 1938. In Britain, too, background research began most notably with Huxley and Bernal. (Godin 2016, 648–50)

that could be allocated to processes and organisational structures. Godin argues that the linear model of innovation was not a social reality that was uncovered after its emergence. Rather, its construction exercised an effect on the practices it sought to describe. In other words, the linear model of innovation is an artefact of science policy rather than a social or economic reality (Godin 2016, 660).

Godin's historical analysis thus shows that Bush (1945) merely implemented a model, which had evolved in the first half of the 20th century. In the wake of this type of science policy, more actors engaged, most notably the OECD. With its Frascati manual (1963), the OECD aimed at establishing a standard form of measuring and thereby allowing analysis and international comparison.

Godin is quite clear about the fact that economists started to contribute to the development of the linear model rather late (Godin 2016, 654). Contributions to the development of the linear model can be found from the 1960s onwards. Now the outcome of scientific research and development became further detailed and was framed in terms of innovation. The economic study of innovation goes back to Josef Schumpeter's work during the 1930s (Schumpeter 1939). But as Godin points out, Schumpeter drew attention to the significance of innovation to economic developments, but did not have much to say about the role of science in this respect (Godin 2016, 655).[25] With its beginning during the 1960s, scientific knowledge production has today become a central element of neoclassical economy as prominently expressed by the OECD and its policy recommendations (OECD 2011; 2010; 2001). In other words, the linear model of innovation is an artefact of science policy within neoclassical economy.

Altogether, Godin's analysis reveals the historical development of a particular (re)framing of the science and society relationship in economic terms. With its beginnings amongst industrialists in the early 20th century, the economic perspective was gaining ground amongst policy makers. After the Second World War the linear model of innovation became dominant in Western societies and was heavily promoted by the OECD. Godin points out that despite frequent criticism (Rosenberg 1994)[26] the linear model of innovation has become a "social fact" and today is taken for granted. With science increasingly being regarded as a powerhouse of economic growth, the public sphere became synonymous with the marketplace – a process Ulrich Bröckling et al. (2000) have described as the "economisation of the social" (2000, 16). To begin with, the social sphere was a rather abstract category conceptualised in terms of Gross Domestic Product (GDP). The public was not framed as a collective of actors; not even as (passive) consumers. Early contributions were made by Everet

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[25] "Suggesting that "Schumpeter regarded the process of innovation as central to an understanding of economic growth" but that he "did not devote much attention to the role of science," Maclaurin "broke down the process of technological advance into elements that may eventually be more measurable."(Godin 2016, 655)

[26] Rosenberg even claims that the linear model is dead, and everyone would know that (Godin 2006, p. 640). Godin, too, reveals the controversial reception of the economic significance of basic research and its funding. To demonstrate his point, Godin quotes a study by the U.S. Department of Defense, which found in a study of 1969 that only 0.3 percent of innovations events came from undirected research and contrasts it with a study by the NSF claimed that is was in fact as much as 70 percent (cf. Godin 2006, p. 659). Godin concludes: "Equally, very few accurate numbers on the costs of innovation have come from the official innovation surveys, at least not numbers robust enough to supplement R&D figures (Godin 2005b). All in all, the success of the linear model suggests how statistics often are required to give (long) life to concepts but also how their absence is a limitation in changing analytical models and frameworks." (Godin 2006, p. 660).

Rogers (Rogers 1995) who investigated diffusion processes as an important aspect of the uptake of social or technological innovations by its users. In 1983, Rogers published a revised version of his book and presented a six-stage model comprising: "needs/problems, research, development, commercialization, diffusion and adoption, and consequences" (Rogers 1995 [1985]). Emerging social studies of science and technology were especially critical of this portrait of socio-technical change (Bijker 1995; Pinch and Bijker 1984).

3.3 Discovering the Science-Society Relationship as an Object of Study

3.3.1 Discovering the Science and Society Relationship as an Object of Study

In his book "Science in Society", Matthew David (2005) notes that "[t]he Idea that science was itself something that could be studied sociologically took a long time to emerge" (2005, 3). According to him, this quest began somewhat tentatively with Marx and Engels who argued that science would be a material force dispelling illusions but would also be "and ideological superstructure of capitalism" (David 2005, 4). Max Weber, too, showed some sociological interest in "Science as a Vocation" (Weber 2002, 474–511). In France, Emile Durkheim contributed to the way in which science was framed in sociological terms. This led to the idea "of the social foundations of 'ways of seeing'" which "were to prefigure subsequent developments in the 'sociology of science'" (David 2005, 5).

The first social theorist to make knowledge an object of sociological enquiry, however, was Karl Mannheim with his book "Ideology and Utopia" (1929). For Mannheim, knowledge depended on a person's social position (Heintz 1993, 530). This "Seinsverbundenheit" (connection to existence or being in the world) of knowledge resonates with later ideas of "situated knowledge" (Haraway 1988; Harding 1986). In other words, Mannheim introduced a particular type of relationship between knowledge and the public. It is important to note that Mannheim promoted a relational analysis and not relativism (Heintz 1993, 531). Although for Mannheim it was evident that there could be no privileged access to any form of knowledge, he treated scientific knowledge (natural science and mathematics) as an exception. Thereby he introduced a division between the sociology of knowledge and the sociology of scientific knowledge. In any case, he saw it as a task of sociological enquiry to explain the "situated" nature of knowledge (Heintz 1993, 532).

However, before sociologists started to develop Mannheim's research programme further, they were primarily interested in the social function of science, which meant that the epistemological aspects of scientific knowledge remained untouched and unchallenged. Robert Merton is commonly cited as the founder of a sociology of science, as his aim was to explain scientific knowledge "in relation to the economic conditions underpinning its production" (David, 2005, p. 10). In this sense, Merton was closer to Weber than to Mannheim. However, even in Merton's work epistemological aspects remained largely untouched: "Following Weber in looking at socio-psychological drivers of modern thinking, Merton resisted, as did Weber, the temptation to question the 'truth' of modern western science" (David 2005; for a critical view, see Heintz 1993, 536). With that, Merton is clearly a pioneer in studying aspects of the science and society relationship, but not the practice of truth-making itself.

The first one who did just that was the philosopher[27] and historian of science Thomas Kuhn. Kuhn suggested that empirical research is theory-laden (David 2005, 13) and that science progresses by way of phases of normal sciences undergoing periodic "paradigm shifts". Paradigm shifts occur when research increasingly produces anomalies normal science is unable to deal with. Kuhn's point was that paradigm shifts essentially constitute a social process. Consensus-building around a new paradigm is social in nature. Yet, Kuhn focussed largely on inner-scientific dynamics without paying much attention to the science-society relationship. The sociological explanation of these dynamics was, however, something that was taken up by sociologists from the UK, although not without criticising and changing Kuhn's ideas.

The radical twist in the sociology of science can be associated with the formation of the sociology of scientific knowledge (SSK) in the UK. Different groups around Michael Mulkay (1969), Barry Barnes (1974), David Bloor (1976), Harry Collins (1985) and others started to inquire into the social processes of scientific truth-making. Some of these authors inquired into the internal social dynamics of scientific practices (Heintz 1993, 538). Studying the relevance of external factors would soon follow and brought the study of the science and society relationship closer to the world of politics.

3.3.2 Science Policy

Despite its long and multifaceted history, the science and society relationship moved centre-stage only after World War II (Felt 2003, 19). An indicator for this considerable shift is national governments' move towards governing the science and society relationship. Brian Wynne gives two reasons for that: the so called "Sputnik shock" and an ever-growing demand for public funding of scientific research and technological development (Irwin and Wynne 1996). After World War II it became apparent that science (and technology) was in need of governance. It was also around that time sociological interest in the science and society relationship started to develop (Merton 1973).

Post war science policies were informed by the broadly shared conviction that science played a major role during the war and contributed significantly to the allies' victory. In the USA, Vannevar Bush authored science policies during and after the war (in the UK, too, scientists advocated the positive "social function of science" (Bernal 1939). According to this doctrine, science was expected to contribute to economic growth and wider societal needs in times of peace. Two aspects are important: a) the "science as endless frontier" rhetoric drew on earlier ideas of how scientific knowledge leads to economic outputs (cf. linear model of innovation) and b) policy makers increasingly began to ask how the social sciences could contribute to societal goals as well. This interest in the merits of the social sciences triggered a debate over the structure of governmental funding. In the USA, this spawned a controversy over whether the social sciences should receive funding through the NSF or not (Gieryn 1999).

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[27] Other philosophers at the time also suggested that scientific theories were empirically "underdetermined" and observation would necessarily be "theory induced" (Heintz :534; see Duhem-(Neurath)-Quine thesis). This development in the philosophy of science is commonly referred to as "anti-positivist turn" (Heintz : 533).

Over the course of the second half of the 20th century, many governments developed a considerable apparatus of expert advice. Comprising virtually all branches across natural, social and medical sciences and engineering expert advice became a core element of policy making (Hilgartner 2000, 21).[28]

> "Behind the headlines of our time stands an unobtrusive army of science advisors. Panels of scientific, medical and engineering experts evaluate the safety of the food we eat, the drugs we take, and the cars we drive." (Hilgartner 2000, 3)

Hilgartner's research takes issue with the credibility of expert advice, not its actual uptake[29], although he notes that it involves a lot of "impression management". Consulted experts make considerable efforts to influence how decision makers should perceive their advice. However, we still do not know much about the receivers' side – how policy makers' make use of evidence. Hilgartner suggests that there is a problem of access. The practices around expert advice lead to such limited access and even secrecy (Hilgartner 2000, 19). Thus, he concludes that the backstage remains largely hidden and inaccessible. However, more recent work has uncovered in more detail how backstage processes are essential for producing acceptable policy advice (Bekker et al. 2010).

As much as science had been recognised in the meantime for its contribution to societal goals, its relevance was also contested from the late 1960s onwards (Rip 2014, 4–5). Critics voiced environmental and political concerns or questioned science for its affiliation with the military and its contribution towards stabilising power relations (Shapin 2012, 16). Indeed, during the 1960s and 1970s several prominent controversial issues came to the fore, including reproductive medicine and genetic engineering (Fox Keller 2001; Katz-Rothman 1989; Rapp 2001). These controversies proved to be critical challenges to science (by various social actors) and contributed to raising moral issues about the extent to which scientists can be held responsible for the consequences of their work. A familiar response to such contestation is the attempt to separate science from society and attribute social, ethical and political issues to other social actors (better qualified, more responsible or legitimate). Here we can observe the recurrent advocacy of "pure science" as a form of truth making that is not polluted with politics. This response is reiterated in recent attempts to reconcile democratic and epistemic claims to policymaking (Krick 2019).

Jerry Ravetz expressed this type of boundary work in a famous aphorism: "Science takes credit for penicillin, but Society takes the blame for the Bomb" (Ravetz,1975; cited after Rip 2014, 4). This ambiguity (or double strategy) is characteristic for the present-day relationship between science and society as well. Scientists frequently claim and defend an image of curiosity-driven "pure science" whenever they seek to fend off

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[28] Hilgartner notes: "Yet, during the half-century since World War II, especially since the 1960s, the [National] Academy [of Sciences] has served as an important actor in the U.S. state, and it is generally considered a 'quasi-official organization'. Its congressional charter explicitly directs it to provide advice on scientific matter to the U.S. government." (Hilgartner 2000: 21). He goes on: "How Academy advice fits into governmental decision making varies with the substantive area, but it enjoys considerable influence." (ibid. 21).
[29] His "theatrical metaphor also helps to address the reception of advice", although, he does not say much about that (Hilgartner, 2000, p. 8).

interference from outsiders, while at the same time present convincing evidence for their decisive contribution to economic growth and other societal needs when applying for funding.

Recent requests for "responsible research and innovation" can be taken to indicate that the accustomed division of moral labour is under contestation.[30] These attempts include efforts to bring a variety of social actors into the realm of science. The participation of lay people, citizens, consumers and civil society actors has been given different names (public understanding, public engagement, citizen science, transdisciplinary research, co-creation etc.) and comprises various activities including communication, deliberation, decision-making as well as knowledge production and innovation. However, these efforts seem to have a limit, as became evident in the form of "engagement fatigue" (Rip 2014, 5). Yet, as Jasanoff has pointed out, "fatigue" was an insufficient description: "By the turn of the twenty-first century, however, signs of friction set in. (…) Increased participation raised fears of a new populism, resistant to modernization, technological progress, and the benefits of globalisation." (Jasanoff 2012, 14). Questioning the existing arrangements of the "division of moral labour" is in itself an ethical question that refuses to take the current state for granted (Rip 2014, 5).

As the focus of science policies lies on societal goals such as economic growth, public health and so on, less attention was payed to the composition of this collective of people. However, who was this society that became framed as the benefiter of scientific progress?

3.3.3 The Popularisation of Science

Science popularisation is not an invention of the 20th century. The natural world had been popularized even before the advent of modern science. This included collections of natural artefacts in museums as well as popular writings on matters of the natural world ranging from astronomy to medicine (Wolfschmidt 2002, 79). Long before modern science became more rigorously defined, there were forms of display and narration of the natural world conveying the contemporary knowledge to a wider (mostly bourgeois) audience. These practices did not disappear with the development of modern science but increasingly departed from scientific practices in language and style (Baasner 2002, 41). Nevertheless, popularisation accompanied scientific conduct all through the Enlightenment and beyond (Baasner 2002, 39).

Despite its long tradition, the popularisation of science became an object of study much later, as Ulrike Felt points out:

"While science communication to selected lay-audiences had taken place already for some centuries, more systematic reflections on the role, meaning and impact of it both on society as well as on the science system have only started in the second half of the 20th century" (Felt 2003, 19).

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[30] A similar division of labour can be found in the relationship between industry and governmental actors. Industrialists point to their need to pursue profit in order to survive and make others to take care of (possibly negative) second-order effects (Rip 2014, 5). This arrangement has been challenged and tried to overcome by ideas of corporate social responsibility (Ing and Lenox 2000).

After World War II, society was mainly framed as an ignorant audience that knew (too) little about science. Consequently, ordinary people were encouraged to learn about science and its merits. According to this particular framing, which lasted until the 1970s, the main obstacle to public understanding of science was the incomprehensible language of scientists. Therefore, scientific knowledge would have to be "translated" into the vernacular of ordinary citizens. With the identification of the main problem, science communication became the focal point of intervention. Brian Wynne and others have characterised the corresponding style of communication as the "deficit model", since its promoters focus on a deficient public who does not know, but needs to be told about science (Wynne 1995; 1993). The main features of the deficit model are 1) a (knowledge) hierarchy between scientists and their lay audiences, 2) a one-way communication from those who know (the scientists) to those who are ignorant (the lay-people), 3) a focus on textbook knowledge and 4) the expectation that lay-people will appreciate science and its achievements[31] (Felt 2003, 16, 20, 25).

With its underlying sender-receiver model of communication this framing of the science and society relationship foregrounds a new type of actor: the science communicator (often journalists) competent in translating between the language of experts and lay-people (Weingart 2001). Science communicators do not only act as mediators, but they also implicitly reinforce the social status of scientists and their epistemic authority. As was already mentioned in the introduction, the "enlightenment model" is not an invention of post-war science popularisation. As described above, its history is much longer. Furthermore, this type of science communication has not disappeared, but is still part of contemporary practices and thereby perpetuates the deficit model (Felt 2003, 19).

The next shift of the science and society relationship occurred when citizens began to voice their doubts about the promises of the social benefits of science and technology during the 1970s, and "society" became "the public". The framing of society and its relationship to science changed once more.

3.3.4 Contestation and Debate

Although contestation and controversy is certainly not the only way to characterise the science and society relationship, this framing has become predominant since the 1970ies (Bauer 1995, 2).[32] There are a number of well-researched cases where different social groups called into question the desired "autonomy" of science and its benefits to societal needs.

One of these examples is the controversy over recombinant DNA technologies that unfolded in the USA in the 1970s. DNA sequences coding an antibiotics-resistant protein had been used as a marker to verify successful recombination of DNA molecules. At the time, nobody knew how to assess the associated risks and how to handle possible adverse effects. The problem became a public concern and led to open protests,

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[31] Felt 2003 argues along these lines regarding the "idea of social and economic progress through scientific and technological advances" (ibid. p. 16).

[32] There are of course earlier chapters of "resistance to technology" as Martin Bauer points out: "The nineteen contributions compare forms and effects of resistance across time, space and technology: from machine breaking and technology transfer in the nineteenth century, Fordism in the early twentieth century, to three base technologies after 1945: civil nuclear power, information technology, and new biotechnology." (Bauer 1995, 2)

turning the ensuing controversy both public and scientific. Scientists were concerned about laboratory safety and eventually called for a moratorium of recombinant DNA technologies (P. Berg et al. 1975; for more on the Berg letter and the Asilomar conference, see Gottweis 1998). The moratorium proposed by Paul Berg pursued a number of goals. First, it bought time to develop laboratory standards, safety protocols and to assess the suggested hazards. Second, it sought to pacify the public controversy, and third, the moratorium was a type of boundary work. Scientists intended to demonstrate that they were capable of handling the issue amongst themselves and thus maintain – if not "autonomy" – at least authority over (the governance) of scientific research.

In the 1970s, more controversies challenged accustomed arrangements of the science and society relationship. DNA technologies were also seen in relation to reproductive technologies and abortion. As part of a larger quest for self-determination in reproductive matters, feminists interpreted in-vitro fertilisation and prenatal genetic diagnosis as patriarchal attempts to impose control over women's bodies. Women engaged and fought for their right to have a say in these matters (Petchesky 1981) and thereby challenged male authority over reproductive technologies. As early as 1975, Dorothy Nelkin put it in critical terms:

> "The complexity of public decisions seems to require highly specialised and esoteric knowledge, and those who control this knowledge have considerable power. Yet democratic ideology suggests that people must be able to influence policy decisions that affect their lives" (Nelkin 1975, 37).

The list of public controversies related to science and technology is long. Since the 1970s, environmental concerns have played a considerable role in this regard. The Peace movement and anti-Vietnam-war movements fuelled protests against the engagement of scientists in war efforts and military technology. Anti-Nuclear protests, too, were prominent in questioning the role of scientists in this domain (Bauer 1995, 6; Winner 1980). But even information technologies were received critically and continue to give rise to public resistance (Bauer 1995, 9; on early privacy concerns see Nelkin in 1995, 379–92).

However, citizens did not only protest, but some actively sought to develop alternatives. Especially in the energy sector, grassroots innovation contributed to the development of wind turbines and solar panels, to give but one example (Ornetzeder and Rohracher 2013). Here the relationship between science and the public takes a different route. Citizens are framed as users and consumers of technologies rather than as an ignorant public (Oudshoorn and Pinch 2008).

The bottom line is that the public started to engage with science, sometimes uninvited and occasionally disruptive, sometimes sought after and constructive. In any case, different social groups decided to voice their opinions, engage and contribute to both knowledge production and technological innovation.

> "Alternative knowledge forms started to claim their place in societal decision making, thus questioning the classical model of decision-making based on technoscientific expertise. In this context the classical linear communication models also started to be questioned" (Felt 2003, 21).

Despite these early signs of change, the main response to public protests and contestation was still strongly rooted in the enlightenment model focussing on public perception, awareness and understanding. The goal

of such educational efforts was to obtain a higher degree of acceptance especially for controversial cases of science and technology.

Also around that time, a number of countries (especially in North America, Scandinavia and Western Europe) established Technology Assessment (TA) as a way of informing policy decisions. The Netherlands stand out in this development with their attempts to integrate perspectives of ordinary citizens into the assessment (for Constructive Technology Assessment, see e.g. Rip, Misa, and Schot 1995; Bekker et al. 2010). Soon, other countries followed suit and developed similar participatory forms of Technology Assessment (Grunwald 2002, 127). These developments are important because they allow us to trace early practices by which policy makers were addressed as receivers of scientific expertise.

Social scientists, too, started to investigate controversies and analysed how citizens and scientists negotiated their relationships over the course of protest and contestation. These studies also contributed to the deconstruction of imaginations of laypeople as ignorant and in need of science education and generally incapable of making informed choices when it comes to technological developments (Bauer 1995; Nelkin 1975).

3.3.5 Technology Assessment

Technology Assessment (TA) deserves more attention than this summary can provide. However, it is important to note that technology assessment is an institutional response to specific circumstances. The establishment of TA offices should not be taken to mean that social, economic and environmental effects of technology became the subject of critical reflection for the first time. Rather it is the case that in a particular historical situation some countries (first the USA[33] and Europe not much later[34]) decided to establish information services for parliamentarians (Grunwald 2002, 48). This background indicates that TA is concerned with the political challenge to engaging national parliaments in the shaping of technology. The basic assumption behind this institutional innovation was that technology is not the result of an inner, scientific logic and thus open to shaping. Thus, at the heart of TA lies the refutation of technological

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[33] The U.S.A. were the first country in which technology assessment became established. The so called "Office of Technology Assessment" (OTA) was founded in 1972 as a parliamentarian institution. Its explicit goal was to provide expertise to the US Congress (Grunwald 2002, 100). One important reason that lead to the installation of the OTA was an imbalance between government and parliament with the latter lacking resources and expertise to fulfil its task as legislative and control function.

[34] European organizations of technology assessment include respective institutions at the European Parliament (the so-called Scientific and Technological Options Assessment) fronded by the end of the 1980s. The Dutch Rathenau Institute is one of the first European examples, founded in 1986 as "The Netherlands Office of Technology Assessment (NOTA) (Grunwald 2002, 108). From the beginning the Netherlands put an emphasis on broader public deliberation of technology and its effects. In the United Kingdom the Parliamentary Office of Science and Technology (POST) is an early example. Starting on the basis of private donations during 1989 and 1992, the UK Parliament later secured its public funding (Grunwald 2002, p. 107). In Germany, the Büro für Technikfolgen-Abschätzung beim Deutschen Bundestag (TAB) was founded in 1990. European TA organisations founded a network in 1990, The „European Parliamentary Technology Assessment Network (EPTA, www. Eptanetwork.org) with its founding members from the Netherlands, Denmark, France, (ibid., p. 109).

determinism. Accordingly, the question fundamental to TA concerns how and by whom this type of advice should be given (Grunwald 2002, 38). This again raises questions of democratic deliberation and the role of scientific experts in this context.

Deliberation over possible ways of shaping technology towards a desirable trajectory puts the science and society relationship on the table. Being located in parliaments, TA was a public concern from the beginning. While earlier forms of TA had been expert-centred, the appreciation of participatory elements and the engagement of wider social groups became increasingly important from the 1980s onwards (Grunwald 2002, 127). This participatory turn in TA has a particularly strong tradition in the Netherlands (Bekker et al. 2010) and Denmark from where it spread to other countries in Europe, North-America and beyond (e.g. Rip, Misa, and Schot 1995).

The appreciation and integration of participatory elements into the assessment of technological development is especially important. It has been influential for the science and society relationship in various ways. Many of the methods and proceedings of participation had been developed in the context of technology assessment (Grunwald 2002, 111) before being applied to the deliberation of scientific research more generally. In this sense, participatory TA had a significant influence on the science and society relationship and paved the way for subsequent practices of public engagement and participation. Still, it should be noted that these developments are not separate or consecutive events. Rather, participatory TA and public engagement in the deliberation of science policy are closely intertwined and mutually influential.

3.3.6 The Funding Crises

Alan Irwin notes that "the mid-1980s were a time of great anxiety about the future of public support for science" (Irwin 1995, 12). In the UK and beyond, neoliberal policies had been having immediate effects on science policy and the practice of research since the 1980s. The neoliberal doctrine centred around the economic utility of scientific research. The hope was to kill two birds with one stone, as in the case of research yielding economically useful outputs, industry would happily provide the funds for research. In this way, the reasoning continued, one type of (applied) science would have no difficulties to survive (if it contributed to the development of marketable products) and the rest was allegedly not worth to keep alive. Especially in the UK, where such type of neoliberal policies proliferated during the 1980s, the threat to academia was enormous. As a response to contemporary governments, scientists actively sought to promote science, which led to considerable efforts to demonstrate the invaluable contribution of scientific activities to the common good and economic growth. Scientists concluded that they needed to mobilise allies in order to convince policymakers of the importance of science. Recruiting the public as an ally and communicating the importance of science to the public was part of this strategy. Once more, scientists deployed the enlightenment model to reach a lay audience with the ultimate goal to mobilise public support for governmental funding of scientific research.[35] As a central element of this strategy, the Royal Society

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[35] Parallels to the 19th century enlightenment discourse are striking (Felt 2003, 23). Furthermore, Felt notes: "In that sense the PUS movement could be interpreted, at least in those parts that followed the argumentative logics of the

commissioned a report on "The Public Understanding of Science" (Bodmer 1985). As the results of this study showed: the British public in fact knew very little about science.

The authors of the 1985 report of the Royal Society presented arguments as to why the public should know more about science. Such "better public understanding of science can be a major element in promoting national prosperity, in raising the quality of public and private decision making and in enriching the life of the individual. (…) Improving the public understanding of science is an investment in the future, not a luxury to be indulged in if and when resources allow." (Bodmer 1985, 9).

The important point is that the competition for scarce resources plays a grave role in the public understanding of science agenda and this context is important for understand the ways in which the relationship between science and society has developed since the 1980s. As in earlier science communication practices, in the PUS framing the public is framed as ignorant and accordingly in need of education. The PUS frame clearly subscribes to the deficit model (Felt 2003, 23), where the public is modelled as a passive receiver of scientific truth without being actively involved in processes of knowledge production. However, it should be noted that the public is not merely framed as a threat but as a resource to be mobilized for putting pressure on policy makers whenever the latter announced to cut public funds for scientific research (Wynne 1996). The construction of a lay public "has turned out, in application, to be enormously disempowering of citizens" (Jasanoff 2012, 26).

Behind these efforts to improve public understanding of science lies the assumption of a correlation between knowledge and acceptance of (or support for) science. Meanwhile, a lot of empirical work has shown that such a correlation is insignificant if it exists at all (Felt 2003, 26 see also Eurobarometer 55.2). Despite empirical insight, there are still many who believe in the creation of public support for scientific research through informing the public.

Quite obviously, scientists increasingly drew on utilitarian discourses in order to demonstrate their contribution to tackling social challenges. This discourse was not exclusively deployed by scientists. Funding agencies, too, play a decisive role in the framing of the science and society relationship in utilitarian terms. In the EU, the European Commission demands from applicants through the design of the so-called framework programmes to explain how their work contributes to a set of policy goals. Economic growth ranks highest on this normative agenda of the grand challenges. It is therefore hardly surprising that scientists learned to play to the tune of economic growth and societal needs. Whenever links between scientific processes and decision-making processes were made, some form of basic understanding of science was viewed as a precondition for meaningful participation of laypeople (Bodmer 1985, n. 10).

Royal Society Report on PUS published in 1985, as a far-reaching enlightenment programme, with the aim of making people admire, appreciate and support science." (Felt 2003:16)

Social scientists measured levels of textbook knowledge (also referred to as "scientific literacy") amongst ordinary citizens and carried out quantitative surveys across Europe (cf. Eurobarometer 55.2).[36] Other studies applied a qualitative approach to study how citizens attribute meaning to scientific knowledge. As the research showed, there was not so much a lack of knowledge about science as a considerable lack of trust in the science system and in scientists (Felt 2003, 26). Even more critically, Sheila Jasanoff notes

> "As critics have repeatedly observed, PUS surveys do not merely test a respondent's understanding of science: they simultaneously construct the respondent as a particular kind of knower, or more accurately a *non*-knower" (Jasanoff 2012, 27; Wynne 1996, 380–88).

The focus on trust stems from scientific controversies at the time and was profoundly articulated in the UK and in Scandinavia (mutual mistrust is also a recurring theme in more recent literature on the evidence-policy-gap). More than anything else, the ways in which governments dealt with nuclear energy and recent incidents contributed to public distrust (Paine 1992; Wynne 1996).

A decade after the Chernobyl accident, Europe was struck by "mad cow disease" (also known as Bovine Spongiform Encephalopathy, or BSE) (Irwin 1995, 21 f.). The epidemic was especially severe in the UK. Scientists' credibility suffered a great deal from their apparent shortcomings in advising the government on how to handle the crises. Consequently, the relationship between science and the public was found to be burdened by low levels of trust (Hilgartner 2000).[37] It is somewhat surprising how little was written about diminishing trust in the governments at the time. Policymakers were portrayed as victims to false information and inaccurate science. All that policymakers could be blamed for was that they had indeed listened to the ill advice of scientists. It is striking how little those reports had to say about policymakers as actors in their own right. The vast majority of research (including that of social scientists) focussed on the science and society relationship and ignored the role of policymakers for the most part.

3.3.7 From Dissemination to Participation

Felt (2003) argues that despite the shift from public awareness to understanding "it is still the public that should raise its awareness of science and technology whereas the scientists are not expected to increase their awareness of public expectations and agendas" (ibid. 2003, 17).

> "A practical lesson that emerges from examples like these is that, in today's science and technology-infused democracies, it makes no sense to treat the vast majority of the public as ignorant natives of foreign cultures, as the PUS [Public Understanding of Science] model does" (Jasanoff 2012, 29).

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[36] Studies were carried out in Europe and in North America. "See Miller, John D (1983): The American people and science policy: The role of public attitudes in the policy process. New York: Pergamon; Durant, John R., G.A. Evans and G.P. Thomas (1989): "The Public Understanding of Science", Nature 340 (6 July): 11-14; National Science Board (1989): Science and engineering indicators: 1991. Washington DC: Government Printing Office." (Felt 2003, 24)

[37] See also: Science and Society (2000): http://www.publications.parliament.uk/pa/ld199900/ldsctech/38/3801.htm; as well as the Lord Phillips "BSE Inquiry Report", http://www.bseinquiry.gov.uk/).

With increased efforts to raise public awareness of science and technology, criticism of the instrumental approach to engineer public acceptance of controversial research and innovations became more prominent. Various controversies fuelled these efforts well into the 1990s. The debate on genetically modified organisms (GMOs) played an especially prominent role in this era. However, for life scientists it was not the first time to experience controversy and protests (see above). What may be special about the 1990s is that the controversy appeared at the same time in many European countries, rendering GMOs an issue of European importance (Seifert, 2002). The way in which national governments (and the Commission) initially responded was to intensify communication of the one-way type. But as the controversy evolved and continued, there was more and more willingness to engage in dialogue (Felt 2003, 27). This shift can also be observed on the level of rhetoric. What had been called "public understanding" now became known as "public engagement".[38]

Social science research played a considerable role in this shift.[39] Identification of diminishing trust in science as the main problem made social scientists' promotion of engagement and dialogue quite persuasive internationally.[40] With a growing appreciation of dialogue came the integration of citizens into the decision-making processes.

It seemed progressive to reverse the rationale and request scientists to make greater efforts in "scientists' understanding the public along-side with a public understanding of science" (Felt 2003, 647).

Such efforts took different forms and led to a variety of outcomes. The Danish Consensus Conference (Bekker et al. 2010) was especially successful and became a desired model for many other countries (Grunwald 2002, 131). Sometimes the form of dialogue was less decision-oriented than the Danish model, and the composition of the participants varied, too. Arguably, these forms of deliberative public policy had their heyday in the Genomic era. Attempts were made to transfer and apply them to other emerging technologies such as nanotechnology (Rip 2009). However, it became increasingly apparent that this type of public engagement had its limits. Rip has referred to the situation as "participation fatigue", since it became increasingly difficult to recruit participants willing to e[41]ngage (Rip 2014, 5). In hindsight, we can conclude that the willingness to

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[38] Jasanoff is instructive on this point. She argues that public engagement was a reaction to fears of public participation going too far. She notes: "One reaction against the new demarcationists [who want to keep science and politics separate] has therefore been to push the logic of public participation still more aggressively: 'ubstream,' into processes of research policy and technology design. The call then is for 'public engagement,' a variety of proactive measures to involve people in shaping the purpose of research and the design of technologies." (Jasanoff 2012, 15). See also (Science and Society (2000): Science and Society: Report by the Select Committee appointed to consider Science and Technology. http://www.publications.parliament.uk/pa/ld199900/ldsctech/38/3801.htm; see also the Lord Phillips "BSE Inquiry Report", http://www.bseinquiry.gov.uk/).

[39] The agenda of social scientist was often vested in their own interest to receive public funding and obtain a spot in the antechambers of policy making (see also Felt 2003:674-675).

[40] OECD. Promoting public understanding of science and technology. Paris: OECD, 1997; Science and Society (2000), op.cit. note 23; White Paper dti. Excellence and Opportunity – a science and innovation policy for the 21st century. Department of Trade and Industry, 2001. http://www.dti.gov.uk/ost/aboutost/dtiwhite/; Stifterverband. Memorandum zum "Dialog Wissenschaft und Gesellschaft", 1999 http://www.stifterverband.org

[41]

engage in participatory activities ran out of steam as the controversies over emerging technologies cooled down.

The legacy of controversy-driven engagement, however, is the affirmation of dialogue and interactive modes of participation, which have become mainstream – at least on a rhetorical level. Critical voices claim that recent dialogue-talk largely amounts to paying lip service without having achieved real inclusion of a broader set of societal actors (Felt 2003, 671 f.). We appreciate such criticism and, indeed, asking about the "uptake of open science" is a different way of inquiring into the degrees of public engagement and responsiveness of knowledge production and participatory governance.

Regardless of its actual achievements, it is important to highlight the specific framing of "the public" in the discourse of participation. The participating public is a political category that consist of individuals conceived as political subjects. First and foremost, political subjects (citizens, civil society actors, etc.) are framed as decision makers (Bekker et al. 2010). They make individual decisions as consumers, patients and so on. In addition, they make collective decisions as voters and participants in forms of direct democracy. Their engagement in decision-making predominately concerns the governance of science and technology (regulatory issues, risk governance, etc.). This side of the science and society relationship is strongly pronounced in the political framing as expressed by the term "participation". What is less clear, however, is the ways in which participation also includes the contribution of non-scientists to the actual process of knowledge making.

3.3.8 Social Scientists as Overlooked Intermediary Actors

Many social scientists have studied the relationship between science and society, and many of them have been actively engaged in popularisation and engagement exercises. While professional science communicators and journalists have received some academic attention, the role of social scientists in these various entanglements has largely been neglected and needs to be considered.

Let us briefly consider a typology developed and popularized by Roger Pielke (2007) who describes four (idealized) roles of researchers in policymaking: 1) the pure scientist, 2) the science arbiter, 3) the issue advocate, and 4) the honest broker. The critical point in Pielke's model seems to be the relationship of the issue advocate to research, as the role borders on a lobbying position (Nagasaka, Böcher, and Krott 2016, 149). Based on extensive empirical material, Wieser (2017) identified four different roles that social scientists predominantly assume with respect to policymaking: a) the scholar who remains largely disengaged and seeks to study the science and society relationship, b) a second type of doing just that differs from the scholarly approach with regard to the proximity to the field, c) social scientists take the role of facilitators of public engagement exercises (for this type of engagement, it is important to maintain a neutral position), and d) the role of the advocate (Wieser 2017).

The role of the social scientist can be that of a mediator or spokesperson, i.e. someone who speaks on other people's behalf. In this sense, social scientists act as intermediaries, representing experiences, interests and opinions of those groups they study, allowing different groups to meet and exchange their perspectives as

facilitators of deliberation. Yet, besides their role as facilitators, social scientists tend also to do the reporting of such exercises, which once more puts them in the position of a spokesperson on behalf of others.

In the literature, there are occasional concerns regarding the legitimacy of speaking for others, especially in decision-making processes:

"Who will be those that formulate what is often labelled "social demand", or to formulate it differently, who will speak in the name of the others and how will this figure again the necessary credibility and trust in order to be able to do so? This will be one of the most important challenges for building also a technoscientific Europe in the years to come." (Felt 2003, 673)

Despite all reflexivity, the role of the intermediary actors (including that of social scientists) has hardly been addressed. There are a few notable exceptions, however, e.g. Sebba (2013) who studies the role of research mediators in social science. Intermediary actors promote their own agendas in various ways, frequently concealing their own normative standpoints. As e.g. Nagasaka et al. (2016) have pointed out, the vague relationship to the research process is one of the downsides of understanding the role of issue advocates, in addition to the position being dependent on normative assumptions about the political system. These normative dimensions tend to remain concealed with respect to participatory policymaking. This is not to argue against such initiatives, yet, a call for a more systematic integration of the researcher as intermediary actor.

3.4 Reframing the Science-Society Relationship

As we progress with our reconstruction of the development of the science-society relationship, it becomes increasingly apparent that much of what it uncovers has been around for a long time (if in different forms). Many of the claims put forward by today's science and society advocates are in fact much older, only rediscovered, reshuffled and interpreted in new ways, which is not to say that nothing new has been developed over the past 20 or so years. However, we propose to understand more recent developments in terms of a reframing of the long-term science-society relationship. Understanding earlier developments is especially instructive in trying to understand more recent developments such as RRI and Open Science. The next section therefore describes conspicuous conceptual framings of the science and society relationship over the last 20 or 30 years.

3.4.1 Mode 2 Science, Civic Epistemology and Transdisciplinary Research

One prominent framing developed around the turn of the millennium centred around the question whether ordinary citizens could actually contribute to processes of knowledge production. This involvement was debated under the term "mode 2 science" (Gibbons et al. 1994; Nowotny, Scott, and Gibbons 2001). The promotors of mode 2 science claimed that engaging citizens would not just contribute to the social robustness of truth claims but to knowledge production itself. In other words, the assessment of scientific truth claims in the public sphere (the agora) would not only extend the set of criteria of contestation, but would contribute to the epistemological core of scientific knowledge production. However, critics of Mode-2 such as Peter Weingart argue that the epistemological core of scientific truth-making remains untouched

(Weingart 1999). Whether or not Mode 2 refers to actual changes of scientific practices, the important point here is that Gibbons, Nowotny and their co-authors conceptualize the public epistemological subjects. Mode 2 Science was a popular concept with high visibility, but in hindsight, it was rather short-lived. Nevertheless, its basic tenets inspired other propositions that emerged roughly at the same time (or shortly after the hype around mode 2 science).

Harvard professor Sheila Jasanoff, a long-time observer of the science and society relationship, discusses the ways in which scientific expertise is integrated into policy making (Jasanoff 2005). The central point of her book "Designs on Nature" is that integration does not happen in a universal form but instead depends strongly on the respective "political culture" of a given country. Jasanoff is not concerned with the way scientific truth claims achieve "certainty" (e.g. as a result of scientific proof), but with how "credibility" is achieved amongst specific publics (in her case, the electorate of a given country). In such a way Jasanoff foregrounds the question, how and in what way scientific expertise becomes the knowledge basis for collective (political) decision making. In the book "Designs on Nature" it is however less pronounced how this expertise comes about and to what extent lay-publics contribute to this scientific expertise. Jasanoff's core interest is rather how scientific expertise becomes effective in the realm of political decision making, governance and deliberation (Jasanoff 2005). Clearly, Jasanoff frames "the public" as a collective of political citizens.

A third framing of the science and society relationship known as "transdisciplinary research" (TR) sought to open up the process of knowledge production to non-academic (extramural) societal actors (Bergmann and Schramm 2008; Maasen and Lieven 2006; Mittelstraß 2001; Pregernig 2006). TR's core tenet holds that in order to become socially relevant (and actionable), knowledge (making) needs to include expertise (tacit and explicit) and experiences of all kinds of societal actors, including practitioners, patients, consumers, etc. The integration of non-academic forms of knowledge, the argument goes, increases the chances of such expertise becoming actionable and (socially) effective. These concerns are particularly relevant for agendas of deliberate sociotechnical change (e.g. sustainable food production, energy transition etc.). Therefore, TR was mainly concerned with contributing to and promoting sociotechnical change (Maasen and Lieven 2006; Pregernig 2006). Promoters of TR expect knowledge production to be instrumental to this goal, even if scientific expertise by itself is believed to be insufficient, mainly due to lack of practitioners' and civil society actors' situated knowledge(s). From a TR point of view, societal actors are conceived as relevant producers of knowledge and as contributing to a *more open and inclusive process of knowledge making*.

On the other hand, questions regarding research utilization by policymakers are less pronounced in the TR literature. In fact, within the TR framework knowledge transfer is believed to be a matter of course once a broader set of actors become part of the knowledge production process. Whereas Jasanoff does not take the acquisition of credibility of any type of knowledge for granted, for TR, this is simply out of the question. TR assumes that the key to credibility is the integration of non-academic forms of knowledge and that the expertise of those who are supposed to put knowledge into practice is appreciated and integrated along the way. One important difference to Jasanoff's approach should be noted, however: Jasanoff's "civic epistemology" approach is geared towards formal processes of policy-making, whereas TR's focus, by contrast, is on social and political practices beyond governmental arenas. In other words, TR frames the

public not merely in epistemological terms, but also as agents of change who put relevant knowledge into practice.

Despite considerable differences, all three approaches frame citizens as political and epistemological subjects. As such, citizens produce, assess and apply types of knowledge that go beyond traditional definitions of scientific truth(-making). In this sense, all three approaches promote the idea of opening scientific practices.

3.4.2 The Science Wars

The advancements of (scientific) epistemologies towards more open and more inclusive forms of knowledge-making developed under different headings (e.g. post-structuralism, (social-) constructionism, feminist epistemology etc.) did not go unchallenged. Many representatives of the hard sciences, especially physicists, responded to these attempts of renegotiating the science and society relationship with great concern. To understand this, it is again helpful to recall the wider historical context.

From the 1960s onwards, mainstream epistemologies (i.e. the nomological model) increasingly came under attack (mainly by philosophers and philosophically-minded social scientists such as Adorno, Habermas in Germany and Guattari, Barthes and Foucault in France etc.). During the 1970s, criticism shifted from theoretical to empirical objections. Social scientists began criticising conventional approaches for being detached from what was actually happening in those places where science was made, i.e. laboratories (Collins 1985; Knorr Cetina 1999; Latour 1994; Shapin 1992). Often labelled social constructivist or postmodern positions, these alternative views on scientific knowledge production caused considerable outrage amongst scientists (Hacking, 2001). Well-known scientists (such as Nobel laureate Steven Weinberg) publicly stated their concerns and attacked some of the positions they conceived as inappropriate. The controversy culminated with what has become known as the Sokal hoax. The physicist Alan Sokal wrote a paper by the title "*Transgressing the Boundaries: Towards a Transformative Hermeneutics of Quantum Gravity*" and submitted it to the journal "Social Text" (Sokal 1996a). Following its publication, Sokal declared that his intentions regarding the paper had been merely to ridicule the cultural sciences and especially their journals as, according to him, his paper contained merely plain nonsense. The point he wanted to make was that the cultural sciences would never achieve the natural sciences' (supposed) rigour, and that it was possible to get just about anything published (as he had unmistakably demonstrated) (Sokal 1996b). It is interesting to note that a substantive part of the controversy that ensued took part on the front stage of public media. Science advocates were keen on explaining to a wider public (framed as an attentive, but not contributing audience) what "good science" was all about.

Research on the science wars has concluded that one of the preconditions was a growing discomfort about the diminishing authority and social status of science as such (Bammé 2004; Weingart 2001). Scientists reacted with boundary work (Gieryn 1999) with the aim of re-establishing their epistemic authority which had become increasingly challenged. The point we wish to highlight in this account of the science wars is the presentation of a particular understanding of science. In this recent chapter of negotiating the science-society relationship, Sokal and others drew on accustomed notions of pure science to separate the social domain from the business of scientific truth-making. In this way, the public was conceived simultaneously as an

intruder and an ally. Sokal and the likes of him expected the public to remain disengaged from research, but at the same time serve as an admiring audience, supporting scientists' claims to refute conceptions of more open and socially embedded scientific practices.

3.4.3 Policy Advice and Public Policy

Even though there continue to be new episodes of science wars aiming to establish firm boundaries around "pure science", we can observe the opposite, too. Science has become an integral element of policy making (Hilgartner 2000, 3; Jasanoff 2012).[42] However, this new intimacy surrounding the relationship between science and policymaking is paradoxical. According to the classical view on value judgements, knowledge and politics are and need to be kept separate (Merton 1973; Weber 2002)[43]. Rubio and Baert explain this view:

> "Thus, while politics should concern itself with the sphere of values – with how the world ought to be – knowledge should be exclusively concerned with the sphere of facts – with how the world is. Knowledge, it follows, should be regarded as a mirror that passively registers, without interfering, the essential features and causal relations already existing in the world. To put it differently, knowledge is, and ought to be, value-free, objective and, therefore, apolitical" (Rubio and Baert 2012, 2).

Conventional wisdom holds that science needs to maintain a healthy distance to the world of politics, values, conflicts, passion, desire, emotions, and interest. This is especially true for scientific expertise used to advise policymakers (Hilgartner 2000).[44] Yet, the use of scientific expertise in policy-making is substantial and increasing (Nutley/Webb 2009), a development fraught with tensions and paradox: "If elected officials rely on unelected experts to govern, how can public decisions remain accountable and subject to democratic control" (Jasanoff 2012, 13)?[45] Peter Weingart has argued that besides the *scientification of politics* we can also observe the reverse, the increasing *politicisation of science* (Weingart 1983; 2001). The expectation to contribute to societal needs and economic goals that researchers are increasingly confronted with makes that quite evident. Inevitably, science and technology become political, despite persistent efforts to construct science as pure, objective and impartial knowledge.

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[42] Sheila Jasanoff notes: "Science and technology are commonly taken as drivers of social change. Less visibly but quite centrally, as this book argues, they are also crucially important objects and instruments of politics" (Jasanoff 2012, 11). Nevertheless, Jasanoff sees "science and technology are fitting though strangely neglected subjects for political analysis" (ibid. 11). Hilgartner makes a similar point: "Behind the headlines of our time stands an unobtrusive army of science advisors. Panels of scientific, medical and engineering experts evaluate the safety of the food we eat, the drugs we take, and the cars we drive." (Hilgartner 2000, 3)

[43] (Merton 1973: The Sociology of Science: Theoretical and Empirical Investigations. Chicago: Chicago University Press; Weber 2004: The Vocation Lectures: Science as a Vocation, Politics as a Vocation. London; Hackett, see also Jasanoff in Rubio & Beart 2012, p. 11-32).

[44] In Don K. Price' words, a founder of Harvard University's John F. Kennedy School of Government, "to 'speak truth to power'" (Jasanoff 2012, 14). Yet, Jasanoff, the reporter of these words adds, that science in fact never spoke to power.

[45] Jasanoff continues: "By the 1970s, however, both law and policy reframed the democracy problem as having less to do with experts usurping the role of elected representatives and more to do with experts' lack of accountability to lay publics. Openness became the new watchword, and procedural creativity the chief means to implement it: from transparency rules for advisory committee meetings to freedom of information and expanded opportunities for publics to question administrative decisions" (Jasanoff 2012, 13).

The political nature of technology is evident in the ways in which it affects people's lives. Yet, Jasanoff argues, even though this is a necessary condition, it is by no means sufficient, since "politics and epistemology are somehow related" and "the discourse in which we speak of politics constitutes a knowledge domain that itself needs critical reflection" (2012, 12). Jasanoff's argument is twofold:

"First, divergent accounts of the right relationship between science and democracy reflect historically and culturally situated conceptions of how science governs itself. Second, as articulated into political practice, these theories underwrite radically different constructions of the human subject as political actor and agent of democracy." (Jasanoff 2012, 12).

The relationship between science and policymaking appears increasingly complex when considering practices of participation. As we have outlined before, "the public" rarely speaks for itself. More often, social scientists speak on the public's behalf or represent viewpoints via surveys or qualitative inquiry. Social scientists assume key roles in participatory Technology Assessment and other forms of public engagement. Here, social science serves as facilitator or intermediary actor who conveys public voices to decision-makers. With respect to social science as intermediary, Jasanoff observes an oscillation between two strategies: "first, demarcation, to define and keep well apart the spheres of facts and values; second, participation, to ensure that people's voices are heard and acknowledged deep within the perimeters of technical decision making" (Jasanoff 2012, 13). As members of the public engage in and contribute to political decision making over science and technology they become simultaneously framed as political and knowledgeable citizens.

3.4.4 The Public as Innovator and Creative Resource (Co-Construction)

There is yet another element which plays an increasingly important role in the science and society relationship: innovation. The contribution of science to economic growth has been a recognised factor at least since the early 20th century. What is new, however, is the idea that citizens actively contribute to knowledge utilisation for the development of commercial products (innovation). This idea has many roots. Open Innovation promotes the idea of expanding the innovative capacity of a firm through the integration of external product development (Chesbrough 2015). The principal way of doing this is through the acquisition of small start-ups. Larger companies recognise that valuable innovations emerge outside of the boundaries of their firm. Instead of licensing these products or trying to develop similar products internally, such larger economic actors expand their capacity simply by strategic take-overs of smaller companies with promising products. Companies like Google have taken this model even further in that they do not simply buy innovative start-ups, but instead offer a platform (e.g. an operating system) to anyone who wants to develop a commercial product (e.g. a software application). In this way, the platform owners acquire enormous innovative power and are able to benefit from it without paying the creator of the product who provide the funds for development and bare the risk of failure. Platform economies play an increasingly dominant role in the world economy, especially in the USA. The underlying idea was deemed very attractive and found many followers. Governmental actors and agencies, too, sought to adopt the model of platform economies in their respective (innovation) policies. The declared goal is to find new ways to stimulate the creative potential of the population that had thus far been overlooked and direct it to commercial assets.

Conceptually, work by Etzkowitz, Leydesdorff and Ravetz was quite influential in promoting the idea that the prosperity of innovation depends on successful alignment of actors from three sectors: a) science, b) policy-making, and c) industry (Etzkowitz et al. 2008; Etzkowitz and Leydesdorff 2000; 1990). The ways in which these networks played out in particular parts of North America became a role model for many policy makers worldwide. Elias G. Carayannis and David F.J. Campbell elaborated on the triple helix idea and added civil society to describe what is now called the quadruple helix model (Carayannis and Campbell 2009). With the inclusion of civil society actors, Carayanis and Campbell seek to expand the meaning of innovation from technological to social innovations.

In a fashion similar to corporate forms of open innovation, there are now programmes aiming to do the same in the public domain. The idea is that there is dormant creative potential in the public at large that can be obtained and exploited for innovation, product development, and (ultimately) commercialisation. In other words, governments now try mimic what companies do with respect to open innovation and platform capitalism. Meanwhile, governments have started to launch respective funding programmes to stimulate this kind of civic innovation, an endeavour frequently framed in terms of Open Science. Open Science is certainly more than that. However, it is interesting to observe how science policy actors (governments) utilise Open Science as a vehicle to mobilize the idle creativity of ordinary citizens.

Indeed, there are some very convincing examples of the engagement of lay citizens in scientific knowledge production. The case of AIDS activists in New York is not the only, but a very prominent example of successful engagement. Epstein (1996) has reconstructed the history and social processes by which activists were vital in the development of effective therapies. Epstein's book "Impure Science" indeed presents a very convincing case of co-construction. The story became so persuasive that many tried to repeat it in other contexts and with different policy actors (funding agencies, ministries and EU institutions).

Taken together, these developments constitute a remarkable transformation of the science and society relationship. Most recently, citizens have been modelled as innovators, as dormant potential in need of mobilisation and channelling towards economic utilisation. This new type of citizen is certainly engaged in processes of knowledge production, both scientific and actionable. The future will show whether the framing of the public as political subjects will move to the background or whether such conceptions will exist side by side with economic framings.

3.5 Discussion

It would be perfectly consistent with the structure of this report to include Responsible Research and Innovation (RRI) into the previous section on Re-Framing the Science and Society Relationship. We propose to discuss RRI and OS separately because this separation corresponds with our thesis that neither RRI nor OS are genuinely novel. Indeed, a much better understanding of both RRI and OS is attainable if both are conceived as a re-articulation of existing forms of organising the science and society relationship.

If anything, the present literature review makes it clear that all the elements now associated with RRI and OS have elaborate predecessors, even if the latter sometimes go by different names or stem from different

contexts. This is the analytical point we wish to propose: RRI and OS are a re-articulation of earlier configurations of the science and society relationship. Several of the elements described above are being recombined, regrouped and – most importantly – reframed. To make the point, we have outlined the historical development of the science and society relationship as well as the practices that organise and govern it. However, there are also new elements to be considered, the most conspicuous of which is the normative framing implicit in the term "responsibility" and the Mertonian ethos of scientific conduct (Merton 1973).

3.5.1 RRI

RRI originated in the policy domain, not in academia. First introduced in the "European Commission's Horizon 2020 Program", RRI became a conference topic under the Danish EU Presidency in 2012 (Rip 2014, 1; R. Owen, Macnaghten, and Stilgoe 2012). It is important to note that RRI was invented as a funding opportunity, and many researchers subsequently submitted contributions. Over the course of applying for and then carrying out their projects, beneficiaries began to impose meaning onto what had hitherto been a rather obscure phrase. Although it is fairly undisputed that RRI is a policy invention, it is also true that many researchers and practitioners tried to meaningfully deploy it to social practices with the intent of shaping sociotechnical change. One of the promoters of RRI, Arie Rip, understands RRI as a "social innovation" (Rip 2014, 2). According to Rip, innovation concerns the "division of moral labour", i.e. "the roles and responsibilities of actors and stakeholders in research and innovation" (Rip 2014, 2).

Rip observes similarities to moral concerns which go back as far as the 16th century. The difference to the present context is, however, that the decision whether or not to pursue a certain type of research or innovation is no longer solely attributed to individuals (as it might have been in earlier periods). It is also interesting to note that the term "responsibility" did not exist in the 16th century (Rip 2014, 2). Its present-day meaning in the English language stabilized only in the 18th century (Rip 2014, 3). Today, "responsibility" does not only refer to earlier meanings of personal ethics. As Rip continues, "in the 21st century, the decisions are not individual but part of formal and informal arrangements and authoritative decisions by advisory boards and governmental agencies" (Rip 2014, 2).

With its emphasis on "responsibility" as a defining property, RRI takes a normative stand which is clearly incompatible with the idea of "pure science". Consequently, the promotors of RRI conceive scientific research as a practice that cannot be divorced from social context. The term "responsibility" raises questions regarding the design of research agendas, allocation of funding, and compliance with safety standards and ethical principles. Responsibility encourages the individual researcher to make personal choices and draws attention to the effects of scientific inquiry and the application of scientific knowledge. Equally, RRI rejects technological determinism, presenting technology as allegedly (politically) neutral. It follows from this that processes of technological innovation can be shaped in several ways. It is therefore necessary to deliberate and decide upon the actual route taken in the development of technology. RRI furthermore includes critical reflection and possible adaptation of normative elements of research and innovation. These constitutive features of RRI are a direct consequence of RRI foregrounding a normative framing. Therefore, the individual researcher is framed as a moral subject that is required to make personal choices and to take on individual responsibilities (even though responsible research and innovation goes beyond the individual level).

Meanwhile, RRI has amounted to an impressive body of projects, each seeking to shape practices of responsible scientific research and technological innovation. Important programmatic to RRI were made by Richard Owen and collaborators (R. Owen, Macnaghten, and Stilgoe 2012). Along with other core elements, participation takes a central position in RRI. Here, RRI continues work from previous efforts to engage a wider public into the matters of science and technology.

Some of the literature reviewed here (Olesk, Kaal, and Toom 2019; Tennant, Jacques, and Collister 2016 see also the Budapest Open Access Initiative of 2002) suggests that Open Access (OA) – one of the core elements of RRI – would facilitate knowledge-utilisation in policy making, others object by asserting that accessibility is neither necessary nor sufficient, as it is not the only leverage in this regard (cf. Von Schomberg 2019; Owen & Pansera 2019, p. 32). Hence, if the way in which scientists deliver their outputs to policy makers is not the main problem, the type of knowledge that is at stake is the more relevant. In other words, RRI promotors argue that scientific knowledge will have a greater impact on policy if produced in a different way. What matters, then, is how a more open and thus more responsible form of research affects scientific knowledge production in the first place. Along these lines, RRI promotes institutional change in academia towards rewarding the production of policy- (and society) relevant knowledge.

RRI promotes a new culture of scientific commons (Vermeir 2013). If science operates in a different way, the argument suggests, it will deliver on societal challenges. On this issue, von Schomberg notes: "Open research and scholarship not only relates to the openness of 'knowledge sources', such as data or publications, but also to the openness (and responsiveness) of the knowledge actors towards each other: Open research implies the involvement of all relevant knowledge actors in co-production mode, far beyond the conventional academic realm and might include citizen scientists" (von Schomberg 2019, 13). For scientific knowledge to be relevant for policy making, it is important that research responds to agreed policy goals. Traditional conceptions of science struggle with normative agenda setting. To overcome this problem, RRI justifies such "mission oriented" research through democratic (i.e. involving parliaments, stakeholders and civil society actors) legitimization of research topics. The Grand Societal Challenges as defined by the "Lund Declaration for Europe" (2009) during the Swedish EU presidency and the Global Sustainability Goals[46] are widely regarded as a consensual research agenda of the desired kind (von Schomberg 2019, 5). To further democratic legitimacy, this new type of scientific knowledge production would be carried out in a participatory and inclusive form featuring key elements of RRI (co-creation, co-design). It is through this new (participatory and inclusive) type of research that RRI seeks to re-configure the science-society relationship. This agenda thereby moves beyond improving accessibility of scientific literature. Rather, RRI challenges the ideas that scientific knowledge can be taken for granted and merely constitutes information ready-to-hand for deployment in policy making. The very way in which research questions are defined and whether this process allows for the engagement of societal actors and alignment with agreed policy goals significantly affects the relevance of the respective results. "Societally desirable outputs can take precedence over technological potential while open research and scholarship can provide for insight and options for societally desirable innovations" (von Schomberg 2019, 19). RRI promotors claim that research uptake by policy makers

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[46] https://www.un.org/sustainabledevelopment/

will be increased through closer collaboration between science, society and policy. In this sense, RRI aims for a new science-policy relationship through transformation of research practices. Accordingly, the outcomes of RRI can expect to receive higher levels of uptake by policymakers because they are already aligned with agreed policy agendas (Richard Owen and Pansera 2019, 32). The emphasis on knowledge production puts issues of access to knowledge into perspective, as the question of the societal relevance of research questions is decisive for the policymaking process.

Previous attempts to operationalise RRI have led to its compartmentalization into "six pillars" (European Commission and Directorate-General for Research and Innovation 2012, 3–4) with a rather instrumental interpretation of RRI[47], or the development of indicators to measure the changes brought about by RRI (e.g. the MORRI indicators). This constitutes a simplification, which neither does justice to the potential nor the ambition of RRI. It is equally inappropriate to reduce RRI to an element of OS (or vice versa). There is considerable overlap between OS and RRI as the two share a vision of a new scientific culture (Owen and Pansera 2019, 27–28; Nielsen 2013).

However, to unfold its full potential, RRI requires broader institutional change that includes the political and economic systems as well as sociotechnical configurations. RRI requires a political system that promotes the organisation of collective forms of responsibility through deliberative decision making throughout society (von Schomberg 2007) as well as changes in the economic system such as reconsideration of the role of intellectual property rights and global market mechanisms. Additionally, RRI requires changes to the built environment (e.g. infrastructures) to overcome technological path dependencies. In all of this, RRI builds on earlier concepts and methods from (participatory) Technology Assessment (Grunwald 2002), Anticipatory Governance (Karinen and Guston 2010), Deliberative Governance (Owen, Macnaghten, and Stilgoe 2012), Public Engagement (Felt 2003) and analysis of sociotechnical change (Bijker 1995; Geels 2002). The decidedly novel element RRI brings to the table is its explicitly normative framing (Rip 2014).

However, it would be mistaken to attribute too much formative power to the conceptual framework of RRI and how it was conceived by its designers. How RRI turns out in practice goes beyond programmatic outlines and depends heavily on the concrete guidelines laid down in research programmes (EU framework programmes in particular) and on the ways in which research consortia make sense of such funding opportunities.

3.5.2 Open Science

3.5.2.1 One Term, but a Bundle of Practices

Open Science (OS for short) is an umbrella term for a number of novel practices which aim to bring greater transparency and/or participation to research (Fecher and Friesike 2014). OS encompasses a variety of meanings ranging from publicizing research outputs (Open Access in its various forms) to making accessible

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[47] E.g. the development of an RRI toolbox; see (https://www.rri-tools.eu/about-rri.

all aspects of the research process (Fell 2019), including data (e.g. Giffels 2010), notebooks, analysis plans, and code (Ibanez, Avila, and Aylward 2006; Ram 2013) as well as research evaluation and peer review (Ross-Hellauer 2017; Shanahan and Olsen 2014). OS thereby refers to a bundle of practices and associated key ideas such as reproducibility, accessibility, sharing, and collaboration (Vicente-Saez and Martinez-Fuentes 2018). Free access to research outputs has furthermore been associated to better and more efficient science (Leonelli, Spichtinger, and Prainsack 2015), economic growth (Tennant, Jacques, and Collister 2016), and increased transparency of knowledge production (Gilmore et al. 2017).

OS constitutes a recent intervention into modern science. The concept emerged in the early 2000s, first, under the heading "Science 2.0" (Mirowski 2018; Franzen 2018), and significantly gained momentum in the wake of being integrated into European Research policies (e.g. H2020). OS is in the process of being widely institutionalized to fully enfold its intended benefits to scientific knowledge production and its societal relevance following a growing recognition of its benefits by the scientific community (McKiernan et al. 2016), including policies (both at the national and institutional levels) to increase public access to publicly funded research (Suber 2012) and encourage data sharing (Wallis, Rolando, and Borgman 2013; Couture et al. 2018; Fischer and Zigmond 2010; Fisher and Fortmann 2010; Chokshi, Parker, and Kwiatkowski 2006). Yet, as McKiernan et al. (2016) have pointed out, the main arguments used to promote policies may not address the practical barriers involved in changing researchers' behaviours. In fact, existing incentive structures act as one of the main barriers to the wider adoption of OS practices.

With its goal of making academia more equitable, egalitarian, and transparent, OS is on a par with similar social innovations, especially with RRI. In fact, the ideal of the ivory tower has been called into question at least since the 1960s (Rip 2014). OS and RRI share a vision of enhanced utilization of scientific knowledge towards societal needs and economic prosperity (see Tennant, Jacques, and Collister 2016 for the benefits of OS; see e.g. Rip 2014 for the benefits of RRI). In fact, Open Access has been taken to be a key pillar of RRI. The main thrust of OS is to remove barriers to accessibility and re-use of scientific outputs (publications, research data, and teaching materials). OS takes its point of departure in a critical analysis of what stands in the way of wide reuse of scientific knowledge as produced by conventional scientific practices. Among the benefits of OS practices for researchers have been cited increased citation rates (Piwowar, Day, and Fridsma 2007; Piwowar and Vision 2013), increased media coverage (McKiernan et al. 2016), more transparent research evaluation (Pöschl 2012; Beck et al. 2018), increased reproducibility (Toelch and Ostwald 2018), increased control over research outputs through retaining copyright and publishing under Creative Commons (CC) licenses (McKiernan et al. 2016), and establishment of priority via preprints (Vale and Hyman 2016). OS promotes accessibility of scientific outputs to facilitate uptake, enhance the exchange of ideas and contribute to a more equitable scientific system. OS emphasizes the importance of collaboration and exchange within academia, but also with extramural societal actors.

3.5.2.2   Elements of Open Science

Data sharing is central to the OS agenda (Anagnostou et al. 2015; Andreoli-Versbach and Mueller-Langer 2014; Fecher and Friesike 2014). Accordingly, the publicising research data in digital repositories is a precondition for making them accessible and reusable (Piwowar and Vision 2013). The idea that research data should be shared is condensed in the FAIR principles which mandate that research data be findable,

accessible, interoperable and re-usable (Wilkinson et al. 2016). Sharing of scientific knowledge extends to learning content and materials. Supporters of Open Educational Resources (OER) emphasize the decisive role of the dissemination of scientific knowledge through teaching and learning (Caswell et al. 2008). In particular, as e.g. McKiernan et al. (2016) point out, training of researchers in OS practices early in their careers is fundamental (van den Berg et al. 2017).

As with RRI, socially inclusive forms of knowledge production form a core element of the OS agenda. Drawing on earlier approaches and concepts such as action research, mode 2 science, transdisciplinary research, public engagement and citizen science, OS continues a long-standing agenda of fostering participatory research (Chesbrough 2015). Civil society actors, users, patients, NGOs, industry and other societal stakeholders are not only said to benefit from open access of scientific outputs (Tennant, Jacques, and Collister 2016), but, crucially, are regarded as resourceful contributors to processes of knowledge production.

For that reason, citizen science is highly valued in Open Science as furthering public engagement throughout scientific knowledge production, starting with agenda setting, definition of research questions as well as contributing to data collection and analysis, publication and evaluation of research findings (Vicente-Saez and Martinez-Fuentes 2018). Citizen science is also regarded as facilitating dialogue between science and society (Leonelli, Spichtinger, and Prainsack 2015).

Nevertheless, some elements of OS are complementary to RRI and earlier concepts. For instance, OS fosters transparency in quality assurance, e.g. through promoting novel forms of (open) peer review (Ross-Hellauer 2017). By demanding that scientific truth claims be empirically grounded in a well-documented and reproducible way, OS draws on a broadly shared scientific ethos institutionalized in organized scepticism (Merton 1973). Open Peer review means enhancing quality control through open and transparent review processes (Beck et al. 2018) with the aim of making the evaluation of scientific outputs more productive and participatory through disclosing the identities of both reviewers and authors (Ross-Hellauer 2017).

In sum, OS promotes profound cultural change of the scientific system. However, neither changes on an organizational level (within scientific institutions) nor an individual level will suffice. Rather, profound change is needed in the wider social context in which scientific practices operate. Consideration of these wider preconditions foregrounds the decisive role of infrastructures, science policy, and economic framework conditions.

OS practices depend heavily on digital infrastructures allowing the free exchange of findings and research data (Bardi, Casarosa, and Manghi 2018). Digital technologies are needed for data storage, analysis, publication and dissemination as well as for communication amongst its collaborators and users of scientific outputs. OS principles favour the use of open source software and the publication of research outputs (including findings, primary data, metadata, reviews and other outputs) under open license agreements (Fecher and Friesike 2014). In accordance with RRI principles, OS will only be able to realize its full potential if the desired cultural change of the scientific system is firmly backed up by respective policies to regulate copyright, data protection and licensing (Carroll 2015; Carrozza and Brieva 2015; Caso and Ducato 2014; Pisani et al. 2010).

Finally, Open Science practices require a compatible economic space to develop (critically: Mirowski 2018; Tennant, Jacques, and Collister 2016). Open access publishing and the need for suitable business models is well-argued case in this regard (Suber 2012). However, making scientific outputs freely available requires fundamental changes in the economic system that values and protects intellectual property rights and the privileged access and use of scientific resources and outputs (see RRI) (Ibanez, Avila, and Aylward 2006; Schaeffer 2019; Carroll 2015). OS holds the potential to provide a broader and more accessible knowledge basis for policymaking, in addition to fostering a more open, transparent and inclusive scientific culture with increased responsivity to societal needs.

3.5.3 Alignment of Open Science with RRI

As a social innovation, OS constitutes a unique contribution to the advancement of the science-society relationship. Geared towards societal needs and prosperity, the accessibility of scientific outputs is a necessary, perhaps even indispensable, precondition for a more open, transparent, and inclusive knowledge culture. OS strives to realize this transition by capitalizing on the knowledge resources of a broad set of social actors, while at the same time delivering on social needs and the challenges of our time (Conroy et al. 2019; McKiernan et al. 2016; ElSabry 2017). OS draws on the scientific ethos by emphasizing its inherently public character. In this way, OS stands in a long tradition of changing reconfigurations of the science-society relationship. Aiming to deliver scientific outputs to a broad spectrum of societal actors, OS practitioners can benefit from earlier analysis of the science and society relationship and previous experiences with public engagement and public policy practices. OS proposes novel ways of publishing, sharing, storing and evaluating scientific outputs and therefore holds the potential to advance the quest for social and economic impact of scientific outputs. Sharing many of its central goals with RRI, OS stands to benefit from its alignment with wider efforts to promote changes necessary for the flourishing of inclusive, transparent and accessible scientific practices. Along with changes in the political and economic system, a new scientific culture may come to enfold its full potential.

3.5.4 The Conspicuous Absence of Policymakers

To conclude this summary of the science and society relationship and its development since the emergence of modern science, I would like to draw the reader's attention to an aspect that is largely missing in most of the discussed accounts, and this is the role of policymakers in the science and society relationship. With notable exceptions, as outlined in this report, the presented literature focuses on what science is or ought to be. Respective framings of scientific conduct define the role of individual scientists and what is expected of them (e.g., pure science or utilitarian conceptions of scientific knowledge). Scientists are expected to explain their work to the public to win their support and admiration. Likewise, they are expected to contribute to societal goals, such as public health, public welfare and, perhaps most of all, economic growth.

A second focus lies on the public. Again, previous studies have sought to clarify the composition of the public, what citizens know about science and how they can possibly contribute to processes of knowledge making. People have been framed as laypersons, "the public", citizens, users and even innovators. Each of these objectivations of human beings implies some expectation of what they should know, feel and do in relation to science and technology. These expectations include practices such as to learn about science and technology, to meet new developments with acceptance and even appreciation or if framed differently, to

engage and deliberate in the collective assessment of science and technology. In recent framings, the public was discovered as a valuable source of creative potential which should be directed to contribute to research and innovation.

Policymakers, on the other hand, are conspicuously absent from the analysis. Repeatedly, the focus is on scientists or citizens. Huge amounts of literature have been devoted to investigating the science-society relationship and its constituent practices, but there appears to be a neglect of policymakers as relevant actors. There are exceptions of course, and some of these have been cited in this report (Jasanoff 2005; Hilgartner 2000). For the most part, however, the role of policymakers has been ignored in the analysis of the science-society relationship. This is surprising given policymakers' central position.

Policymakers play a role as instigators. When science became a policy concern, the task of policymakers was (re-)defined as 1) providing funds for research and development, 2) acting upon public ignorance, 3) securing a next generation of scientists and engineers. As a corollary, policymakers were increasingly addressed as recipients of scientific advice (Hilgartner 2000). As controversies arose in relation to particular types of science (such as nuclear science, reproductive medicine, or recombinant DNA technology), policymakers were expected to act as guardians of science. Policymakers are also met with expectations both by the public and the scientific community. Scientists expect policymakers to secure public funding and to actively raise awareness for the merits of science and technology (Felt 2003, 16). Policy makers were also expected to restore public trust in scientific expertise and support scientists in acting upon the credibility of science whenever the latter was under threat. This observation led the authors of this report to inquire more closely into the role of policymakers and more specifically into the uptake of scientific knowledge.

4 Proposed Methodology for Future Work

4.1 Background: Cumulative Advantage in RRI, Open Science, and Policy Making

Scientific knowledge is a key resource for achieving societal and economic goals. RRI promises to fundamentally transform scholarship to bring greater transparency, inclusivity and participation to research processes, and increase the academic, economic and societal impact of research outputs. Yet availability of scientific knowledge via the Internet does not mean uniform access. Might Open Access, as one of the pillars of RRI, sustain or perhaps even deepen the digital divide? How do geographical, socio-economic, cultural and structural conditions lead to peripheral configurations in the European knowledge landscape? What factors foster absorptive capacity and enhance uptake and contribution to the production of scientific knowledge by wider societal, political and economic actors?

For Robert K. Merton (1968), Matthew effects were a consequence of imperfect information that he largely regarded as a functional element that aids determination of the credibility of sources (Lamont 2009). Although Matthew Effects might therefore be functional at the system level, they tend to (dis)advantage the contributions of individuals, as well as the individuals themselves, based on secondary attributes. For Merton, it was the differential allocation of rewards that was problematic (Strevens 2006). Academia can be understood as an attention economy – rewards are largely based on recognition, which in turn is often heavily shaped by an author's place and role in the network.

To a certain extent, this is unsurprising. If someone has a good research profile, it is reasonable to think his or her next work may also be of quality. Yet, what is a "good profile"? The right qualifications, the right institutions, the right style of publications in the right kinds of journals? None of these factors are guarantors of quality in themselves, yet Matthew effects seem to operate also at the level of region, gender, race, and language. It is not simply the *merit* of the researcher's ideas, theories, or experiments that counts, but often where they work, where authors publish, who they know, which demographic groups they represent. Besides symbolic and material rewards for (successful) research, the Matthew effect shapes opportunities (i.e., the allocation of money, people, infrastructures) for doing research itself (Merton 1988). More recent work on the "entrepreneurial university" (Münch 2014) suggests that performance indicators such as the impact factor are highly reactive (Fleck 2013) and therefore exacerbate a quasi-monopolization of resources (prestige, recognition, money) in the hands of relatively few institutions and individual researchers. Enabling more inclusive and participatory research for all stakeholders constitutes a core aim of RRI and Open Science elements like gender equity, access and public engagement.

In the complex relationship between science and society, several developments are crucially relevant for understanding the ways in which contemporary public policies aim at conditions of mutual benefit. The promotion of pure science has been called heavily into question at least since the 1960s (Rip 2014). Beginning with questions of societal relevance of science, environmental concerns became more prominent during the 1970s. Resistance towards recombinant DNA technology with its first wave in the US during the 1970s, and its recurrence in Europe during the 1990s, called traditional arrangements between science and society into question. Today, there is a broad understanding that academic and technological actors can no longer merely

delegate concern about impact to government agencies and societal actors.' "Inclusive governance" has therefore become an important goal for the European Commission since the early 2000s. One important element of these new approaches of "inclusive governance" was the engagement of civil society in various forms of knowledge production, contributing to a wider and more inclusive process of research and innovation as well as political decision-making. Valuable insights into the long history of the governance of science and society lead to questions of whether there is a need for new forms of public engagement. How can we find a way forward when, in the words of Jack Stilgoe, "tools such as public dialogue, constructive technology assessment, foresight or code of conduct [cannot] be taken as panacea" (Stilgoe 2013, xiii)?

Relatively little is known about uptake in policy making practices of the member states, e.g. about which innovation models policy agents and practitioners use and how these mental models "shape what decision-makers pay attention to, what they commit resources to, and how they manage the process". To address these issues, ON-MERRIT combines qualitative and quantitative approaches to study in-depth the interactions between forms of inclusive knowledge production and (deliberative) policymaking to understand how governments and public administration make use of RRI and Open Science resources and participatory processes in creating policy.

ON-MERRIT investigates information-seeking behaviours within governments and parliaments to determine the ways in which open and inclusive forms of knowledge production are included in policymaking. Methods of social inquiry will be used to analyse how scientific resources in general, as well as Open Access and Open Science resources, are in use within policymaking. ON-MERRIT will focus on selected disciplinary cases to determine the ways in which civil society actors influence policy in these key scientific debates, and whose voices are heard on these matters.

4.2 Summary and Research Gaps

Research on the use of evidence in policymaking is frequently criticised for falling short on current theories of the policy process, since a large proportion of empirical work in the area operates on a naïve understanding of research uptake (Cairney 2016). Policy processes need to be better understood before assessing the impact of Open Science. Accordingly, the methodology described in the following pages will be geared towards four questions regarding the use of scientific knowledge by policymakers:

> "Instead of repeating studies of perceptions of barriers and facilitators of use of research evidence, appropriate methods must be used to answer questions about when, why, how and who finds what type of knowledge sound, timely, and relevant at different stages of the policy cycle." (Oliver, Lorenc, and Innvær 2014, 8)

More concretely, both the empirical inquiry (quantitative/qualitative) and the workshops will strive to go beyond terms such as "barrier" and "facilitator". Interviews will be used to gauge contextual factors such as aspects of the policy process and how they impinge on knowledge transfer. In what follows, target groups and target subject areas are specified to identify pertinent research gaps.

4.2.1 Characteristics of Policymakers

Policymakers do not constitute a clearly defined group (Saretzki 2019, 78), but rather involve such diverse actors as politicians, public servants, administrators, and (sometimes) lobbyists and interest groups. Newman

et al. (2016) point towards divisions within the policy community, e.g. between policymakers and administrators. Policymakers' skills in terms of the ability to find and make sense of evidence are found to be a facilitator to research uptake (Cambon et al. 2017; Oliver et al. 2014). Conversely, lack of these skills is often criticised as an ostensive barrier to uptake. Policymakers struggle with knowledge management and a lack of skills to appraise research outputs (Ellen et al. 2011; Head 2015, 7), in addition to a lack of equipment or financial resources, knowledge, attitudes, and skills to utilize research (Ellen et al. 2011). Additionally, policymakers' attitudes (e.g. distrust) towards research can be a barrier (Ellen, Lavis, and Shemer 2016). Policymakers' research awareness is low, and few academics participate directly in the process of decision making (Oliver et al. 2017). Interaction of researchers and policymakers crucially depends on the position of the policymaker within the policymaking process (Haynes et al. 2011). In general, policymakers seek information that is timely, relevant, credible, and available (Head 2015, 7). Evidence is used to reduce uncertainty, but beliefs and emotions also play an important role in choosing a certain problem interpretation (P. Cairney, Oliver, and Wellstead 2016, 399). For those who do not have direct representation, knowledge brokers and intermediary actors play a decisive role. Intermediaries organise and facilitate public engagement processes, e.g. through making sure that every voice can be heard, documenting participatory processes, and conveying results to policy makers. Therefore, knowledge brokers and other intermediary actors are of key interest to the study of the uptake of Open Science outputs in policymaking.

4.2.2 Access to and Consideration of Experts

The literature consistently finds that the main factors to improve research uptake are access to relevant and clear information and good relationships between researchers and policymakers (Oliver, Lorenc, and Innvær 2014, 5). Oral forms of communication are more commonly used than written material. University personnel and extramural academics play a marginal role. Policymakers prefer receiving information through personal contact (Oliver et al. 2017, 120). The most trusted sources of information are government sources as well as advocacy, industry and lobby groups, though some policymakers also mention experts (Dodson, Geary, and Brownson 2015, 844). Above all else, policymakers rely on their personal networks for information (Oliver et al. 2017). Actors providing policymakers with advice (Christensen 2018, 295) can be classified according to their location, i.e. inside or outside public bodies (ibid.). Politicians frequently rely on media presence, reputation and past involvement when selecting experts. Policymakers seek certain kinds of information from certain kinds of people. Data and statistics (demographics of diseases) on prevalence of health issues are the most sought-after information (Dodson, Geary, and Brownson 2015, 842). However, the kind of information sought depends on the functional role of a policymaker (whether policy development regulation, or service delivery) (Head 2016, 475).

4.2.3 Access to and Use of Scientific Outputs

Studies commissioned by ministries are among the main vehicles of knowledge transfer from research to policy, even if such studies are not publicly available and frequently left unused in the policy process (Hermann et al. 2015). Additionally, the studies themselves are often poorly commissioned and there is a lack of coordination between ministries (Olesk, Kaal, and Toom 2019, 3). Information does not come primarily from academic publications. Rather, policymakers prefer governmental agencies and websites (Oliver, Lorenc, and Innvær 2014, 5). Given these preferences, the availability and accessibility of written information in the form of academic publications is of secondary concern (Oliver et al. 2017). Access to data and other research outputs (systematic reviews, individual studies, grey literature) is insufficient to foster research

uptake; policymakers have been found wanting in terms of data interpretation and analysis skills (Lillefjell and Knudtsen 2013).

4.3 Introducing a Methodology to Study Information-Seeking Behaviours and Public Participation

4.3.1 Information-seeking Behaviours amongst Policymakers in the Age of Open Science (Task 5.2)

Survey and interview instruments will be used to directly engage with information services of policy-makers, including parliamentary libraries, party organisations (such as parliamentary clubs in some EU member states) and ministerial resources (e.g. all types of back-office staff) across all EU Member States to ascertain the levels of access to (open and closed) scientific resources, as well as information-seeking strategies of key actors from the three target domains agriculture, climate, and health, bearing in mind that "policymakers" does not denote a homogeneous group but comprises politicians, parliamentarians, civil servants as well as ministry staff. Additionally, the survey will tackle standing advisory boards policymakers consult on a regular basis (organized policy advice).

4.3.1.1 Rationale

A large proportion of the empirical work on research uptake is case based without sufficient contextualization of the multi-faceted processes underlying policy development (Oliver, Lorenc, and Innvær 2014, 4), in addition to having a normative dimension as it focuses on how to increase research uptake (Oliver, Lorenc, and Innvær 2014, 4; Paul Cairney 2016). For the purposes of the present study, knowledge transfer will therefore be regarded as a multifaceted process involving a diverse set of stakeholders in different roles and with varying agendas. The strategies for seeking and considering scientific information can be expected to vary considerably across these sub-groups, in addition to possible variation across national and international contexts (national parliaments and EU institutions) as well as disciplines; the evidence-policy gap appears to be specific to certain academic fields and respective policy contexts.

4.3.1.2 Methodology

The strategy for T5.2 is thus to survey parliaments with respect to their information-seeking behaviours and access to scientific outputs and then to follow up the survey with in-depth interviews. Both survey and interviews will be designed to move beyond the pitfalls of analysing the evidence-policy gap in terms of improving communication of policymakers and researchers to understand policymakers' information needs. Combining surveys and interviews will allow us to gauge the breadth of information-seeking behaviours across institutional and political contexts while delivering contextual information pertaining to aspects of the policy process.

The survey will be administered via online platforms hosted through participant organisations (e.g. LimeSurvey at TU Graz or similar) and distributed across EU member states (plus UK) via email. When

choosing an appropriate service, extra care will be devoted to ensuring compliance with European data protection provisions (GDPR). Parliamentary websites of all target countries have been searched for information on relevant contact points (name, department, role, email address etc.) as well as other potential sources of scientific information such as relevant national intermediary actors. All this information has been collected and completed for all EU member states (plus UK). The sample is split by country and institution with the aim of targeting the three case disciplines (agriculture, climate, health) as best as possible, giving due consideration to the fact that the three target domains do not fall neatly within one political agenda. The target sample may thus comprise more than one institution per country per domain. Such a collection needs to take into account each country's specificities, languages, as well as the parliamentary organization, and highly benefits from the national contacts the project may maintain in these countries. Challenges to this collection are contacts not being available publicly and an uneven distribution of available contact details across countries, areas, organizations.

4.3.1.3   Target Group

National parliaments and ministries of all EU member states (plus UK) will be contacted via email to ask for survey participation. Selected respondents will then be followed up with in-depth interviews across member states and case study areas to shed more light on the role of closed and open access scientific outputs as a knowledge basis of policymaking, as well as ascertaining attitudes towards and experiences of policymaking via open science practices across political actors. The survey will be targeted towards respective national parliaments, their information services and ministries selected based on how well their agendas align with the three ON-MERRIT case studies. With the survey, participants will also be asked to declare whether they would be open to doing a follow-up interview. The target group has been identified through (national) parliamentary and ministry websites which offer information on agendas and responsibilities, as well as (in some cases) on relevant intermediary actors.

4.3.1.4   Survey Content

The survey will cover the following broad topics. Note that this list does not contain any information on how questions will be operationalized into survey items, as this is part of a later stage.

- Nationality, Organization, Role within Organization (Respondent Demographics)
- Open Science
  - Familiarity
  - National Open Science Strategies
  - Open Access to Publications, Open Data, Citizen Science, FAIR Data etc.
  - Attitudes towards Open Science Outputs
- Policymakers' information-seeking strategies
  - Information seeking
    - Communication/consultation within own networks
    - Literature search (university library, national libraries, parliament's library, parliamentary information services)
    - Internet research (newspapers, social media, blogs)

- o Consultation of experts
    - Who is contacted? How are informants identified/chosen?
    - Why are informants contacted? What's a typical situation where experts are contacted?
    - How are experts contacted and by whom?
        - Written communication/oral communication
        - Formal/informal
    - What is the purpose of expert advice (reduce ambiguity/reduce uncertainty?)?
    - The role of public consultations
        - Which members of the general public are contacted?
        - How?
        - For what purpose?
- o Access to scientific outputs
    - Publications: Reading habits
    - Data
        - Do policymakers use scientific data?
        - Under what circumstances?
        - How do they look for data and where?
        - How do they access data?
        - What do they do with scientific data?
    - Other Outputs (blog posts, Social Media, etc.)
- o Information Infrastructures (Kind, purpose, use)
- o Personal information-seeking skills
- o Government-commissioned Research (Why, how, for what purpose, published/unpublished)
- o Role of Knowledge Brokers/Multipliers and institutional policy advice
    - Long-term standing advisory boards (e.g. parliamentary Technology Assessment Offices, Ethics Advisory Boards/Committees etc.)
    - Legal Basis/Applicable Legislature
    - Function/Process
        - When?
        - How?
        - Why?
        - For what purpose?

4.3.1.5 Interview Content

The rationale of the interviews will be to target stakeholders from the diverse group of policymakers to understand the context factors that impinge on research uptake in general and the impact of Open Science more specifically. Respondents will be asked to describe their role in their respective organization and to reflect on concrete examples of policy processes where they sought out expert advice. How was information obtained and for what purpose, and how did respondents make sense of the information provided? How did respondents derive meaning from expert advice, and how did the given expertise inform policy? How were respondents able to effectively use research outputs in policymaking? Based on these interview data, the

researchers in ON-MERRIT will then be able to develop a conceptual model of how information-seeking is achieved in policy processes. These findings will then help to contextualize the quantitative analysis.

4.3.2 Mapping participation in RRI policymaking (Task 5.3)

4.3.2.1 Rationale

RRI practitioners work with a broad range of social actors to engage them in participatory practices to provide a knowledge basis for deliberative policymaking. Especially when authoring project reports, RRI practitioners become spokespersons to both powerful stakeholders and more peripheral civil society actors. Task 5.3 aims to engage these researchers via a series of three expert workshops, each themed for one of the case-study disciplines (broadly: Agriculture, Climate, and Health). Experts invited to these workshops will be asked to share and reflect on their own experiences of participatory processes. In a second step, the experts will then be asked to question how the voices of various stakeholders and civil society actors (including their own) were or were not heard. As Cairney (2016) and others have shown, certain aspects of policy processes might constitute principled barriers to public participation. Without a theoretical account of policy processes, research uptake by policymakers remains unclear (Cairney 2016). Besides, the research reviewed here rarely refers to intermediary actors without connections to academia, e.g. patient groups or other civil society organisations. The workshops will take this glaring research gap into account and contextualize individual accounts of participatory processes by involving experts from policy theory in these workshops. Involvement of policy theory experts in group discussions will allow participants to relate their individual assessment of participatory policymaking to developed theoretical accounts of policy processes. Experiences and reflections of the workshop participants will inform knowledge about Matthew Effects in the participation of public actors in evidence-gathering activities, as well as those which might affect the uptake of research into policymaking. Face to face events are highly impacted by the COVID 19 situation, as travelling is forbidden in many countries and confinement measures are in place, so the workshops may need to be adjusted to this reality.

4.3.2.2 Target Group

The target group for the workshops has been defined as RRI practitioners and other researchers who take part in or facilitate participatory evidence-gathering. That includes intermediary actors such as parliamentary bodies and advocacy (e.g. patient) groups which will be identified through essentially the same channels as the survey/interview participants, e.g. through parliamentary and ministry websites which frequently offer information on intermediary actors. Participants will be contacted personally to the extent possible based on their role as intermediary actor as well as their research interest. Participants will be sampled across Europe and across intermediary institutions.

4.3.2.3 Method and Data

We will strive towards organizing at least one workshop per case study, even though we are aware that this might be unfeasible given the structure of our target population. Each of these workshops will be defined with a view towards the specifics of each case study to feature at least one expert on policy processes within

the respective domain. The expected outcome of all workshops is a policy brief synthesizing the experiences of RRI practitioners in participatory policymaking. Accordingly, all workshop outputs (written and spoken materials) will be recorded for further qualitative content analysis. We expect workshops to yield, among other materials, recordings of focus group discussions, presentation materials (slides, notes, recordings), observation notes (by at least one of the ON-MERRIT researchers present), and posters/other materials crafted by workshop participants. The outcomes of the survey and interviews will help to further contextualize these findings. Through combining the outcomes of all three methods, we hope to be able to cover all (or most) relevant stakeholders in the policy process.

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6 Annex

6.1 Overview of Search Strings

Search Terms (Function)	Database	Hits	Date
((TitleCombined:("Uptake of Open Science")) OR (TitleCombined:("Impact of Open Science")) OR (TitleCombined:("Reception of Open Science")))	TU Graz Library Search	3	15 Oct 2019
((TitleCombined:(Uptake of Open Science)) OR (TitleCombined:(Impact of Open Science)) OR (TitleCombined:(Reception of Open Science)))	TU Graz Library Search	109	15 Oct 2019
((Abstract:("Uptake of Open Science")) OR (Abstract:("Reception of Open Science")) OR (Abstract:(Impact of Open Science)))	TU Graz Library Search	6204	15 Oct 2019
(SubjectTerms:(Uptake OR Reception OR Impact)) AND ("Open Science")	TU Graz Library Search	497	15 Oct 2019
(SubjectTerms:(Uptake OR Reception OR Impact)) AND (SubjectTerms:("Open Science"))	TU Graz Library Search	38	15 Oct 2019
((TitleCombined:(Uptake of Open Science)) OR (TitleCombined:(Impact of Open Science)) OR (TitleCombined:(Reception of Open Science)) AND Policy-making)	TU Graz Library Search	4	15 Oct 2019
((TitleCombined:(Uptake of Open Science)) OR (TitleCombined:(Impact of Open Science)) OR (TitleCombined:(Reception of Open Science)) AND Knowledge Transfer)	TU Graz Library Search	0	15 Oct 2019
((SubjectTerms:(Uptake of Open Science)) OR (SubjectTerms:(Impact of Open Science)) OR (SubjectTerms:(Reception of Open Science))) AND (SubjectTerms:(Knowledge Transfer))	TU Graz Library Search	4	15 Oct 2019
(SubjectTerms:("Policy Making")) AND ((SubjectTerms:("Impact of Open Science")) OR (SubjectTerms:("Uptake of Open Science")) OR (SubjectTerms:("Reception of Open Science")) OR (SubjectTerms:("Knowledge Transfer")))	TU Graz Library Search	53	15 Oct 2019
(SubjectTerms:("Policy Making" OR "Policy Design" OR "Policy Development")) AND ((SubjectTerms:("Impact of Open Science")) OR (SubjectTerms:("Uptake of Open Science")) OR (SubjectTerms:("Reception of Open Science")) OR (SubjectTerms:("Knowledge Transfer")) OR (SubjectTerms:("Knowledge Exchange")))	TU Graz Library Search	81	15/16 Oct 2019
(("Policy Making") OR (SubjectTerms:("Policy Design")) OR (SubjectTerms:("Policy Development")) OR (SubjectTerms:("Participat*"))) AND ((SubjectTerms:("Impact of Open Science")) OR (SubjectTerms:("Uptake of Open Science")) OR (SubjectTerms:("Reception of Open Science")) OR	TU Graz Library Search	294	16 Oct 2019

(SubjectTerms:("Knowledge Transfer")) OR (SubjectTerms:("Knowledge Exchange")))			
((SubjectTerms:("Policy Making" OR "Policy Design" OR "Policy Development")) AND ((SubjectTerms:(Impact)) OR (SubjectTerms:(Uptake)) OR (SubjectTerms:(Reception)) OR (SubjectTerms:("Knowledge Transfer")) OR (SubjectTerms:("Knowledge Exchange"))))	TU Graz Library Search	1922	16 Oct 2019
(SubjectTerms:(Nursing Science)) AND (SubjectTerms:((SubjectTerms:("Policy Making" OR "Policy Design" OR "Policy Development")) AND ((SubjectTerms:("Impact of Open Science")) OR (SubjectTerms:("Uptake of Open Science")) OR (SubjectTerms:("Reception of Open Science")) OR (SubjectTerms:("Knowledge Transfer")) OR (SubjectTerms:("Knowledge Exchange")))))	TU Graz Library Search	4	14 Nov 2019
(TitleCombined:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (TitleCombined:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice"))	TU Graz Library Search	15	14 Nov 2019
(Abstract:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (Abstract:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice")) AND ("Open Science")	TU Graz Library Search	6	14 Nov 2019
(Abstract:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (Abstract:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice")) AND Participat*	TU Graz Library Search	344 (228 available online)	2 Dec 2019
(TitleCombined:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (TitleCombined:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice")) AND Participat*	TU Graz Library Search	5	29 Nov 2019
(TitleCombined:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (TitleCombined:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice" OR "Research Utilization"))	TU Graz Library Search	24	8 Jan 2020
(TitleCombined:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (TitleCombined:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice" OR "Research Utilization")) AND "Open Science"	TU Graz Library Search	0	8 Jan 2020
(TitleCombined:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (TitleCombined:("Knowledge	TU Graz Library Search	8	8 Jan 2020

Query	Source	Count	Date
Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice" OR "Research Utilization")) AND Participat*			
((TitleCombined:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (TitleCombined:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice" OR "Research Utilization"))) AND ("Open Science" OR "Open Access" OR "Open Method*" OR "Open Peer Review" OR "Open Data")	TU Graz Library Search	3	11 Jan 2020
(Abstract:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (Abstract:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice" OR "Research Utilization"))	TU Graz Library Search	754	8 Jan 2020
(Abstract:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (Abstract:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice" OR "Research Utilization")) AND "Open Science"	TU Graz Library Search	6	8 Jan 2020
((Abstract:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (Abstract:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice" OR "Research Utilization"))) AND ((Abstract:("Open Science" OR "Open Access" OR "Open Method*" OR "Open Peer Review" OR "Open Data")) OR (TitleCombined:("Open Science" OR "Open Access" OR "Open Method*" OR "Open Peer Review" OR "Open Data")) OR (SubjectTerms:("Open Science" OR "Open Access" OR "Open Method*" OR "Open Peer Review" OR "Open Data")))	TU Graz Library Search	15 (3 included in analysis)	11 Jan 2020
(Abstract:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (Abstract:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice" OR "Research Utilization")) AND Participat*	TU Graz Library Search	385	8 Jan 2020
("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*") AND TOPIC: ("Impact of Open Science" OR "Uptake of Open Science" OR "Reception of Open Science" OR "Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap")	Web of Science	494	20 Nov 2019
("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*") AND TITLE: ("Impact of Open Science" OR "Uptake of Open Science" OR "Reception of Open Science" OR "Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap")	Web of Science	8	20 Nov 2019
("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*") AND TITLE: ("Impact of Open Science" OR "Uptake of Open Science" OR "Reception of Open Science" OR "Knowledge	Web of Science	9	20 Nov 2019

Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice")			
TOPIC: ("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*") AND TOPIC: ("Impact of Open Science" OR "Uptake of Open Science" OR "Reception of Open Science" OR "Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap") Refined by: TOPIC: (Open Science)	Web of Science	18	20 Nov 2019
TOPIC: ("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*") AND TOPIC: ("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice")	Web of Science	620	20 Nov 2019
("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*") AND TOPIC: ("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice") Refined by: TOPIC: (Open Science)	Web of Science	21	20 Nov 2019
("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*") AND TOPIC: (Uptake OR "Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice")	Web of Science	1435	20 Nov 2019
TOPIC: ("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*") AND TOPIC: (Uptake OR "Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice") Refined by: TOPIC: ("Open Science")	Web of Science	2	20 Nov 2019
("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*") AND TITLE: (Uptake OR "Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice")	Web of Science	16	20 Nov 2019
(Abstract:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (Abstract:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice")) AND Participat*	Web of Science	0	8 Jan 2020
(TitleCombined:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (TitleCombined:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice")) AND Participat*	Web of Science	0	8 Jan 2020
(TITLE-ABS-KEY ("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*") AND TITLE-ABS-KEY (("Impact of Open Science" OR "Uptake of Open Science" OR "Reception of Open Science" OR "Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice")))	Scopus	855	20 Nov 2019
((TITLE-ABS-KEY ("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*") AND TITLE-ABS-KEY (("Impact of Open Science" OR "Uptake of Open Science" OR "Reception of Open Science" OR "Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice")))) AND ("Open Science")	Scopus	6	20 Nov 2019

(TITLE-ABS-KEY ("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*") AND TITLE-ABS-KEY ("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice" OR Uptake))	Scopus	2005	20 Nov 2019
(Abstract:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (Abstract:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice")) AND Participat*	Scopus	0	8 Jan 2020
(TitleCombined:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (TitleCombined:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice")) AND Participat*	Scopus	0	8 Jan 2020
(((("Policy Making"[Title/Abstract] OR "Policy Design"[Title/Abstract] OR "Policy Development"[Title/Abstract] OR "Policy Maker*"[Title/Abstract])) AND (Uptake[Title/Abstract] OR "Knowledge Transfer"[Title/Abstract] OR "Knowledge Exchange"[Title/Abstract] OR "Policy Gap"[Title/Abstract] OR "Policy Advice"[Title/Abstract])) AND "Open Science"[Title/Abstract]	PubMed	0	21 Nov 2019
((("Policy Making"[Title/Abstract] OR "Policy Design"[Title/Abstract] OR "Policy Development"[Title/Abstract] OR "Policy Maker*"[Title/Abstract])) AND (Uptake[Title/Abstract] OR "Knowledge Transfer"[Title/Abstract] OR "Knowledge Exchange"[Title/Abstract] OR "Policy Gap"[Title/Abstract] OR "Policy Advice"[Title/Abstract]))	PubMed	658	21 Nov 2019 until hit #200
((((("Policy Making"[Title/Abstract] OR "Policy Design"[Title/Abstract] OR "Policy Development"[Title/Abstract] OR "Policy Maker*"[Title/Abstract])) AND (Uptake[Title/Abstract] OR "Knowledge Transfer"[Title/Abstract] OR "Knowledge Exchange"[Title/Abstract] OR "Policy Gap"[Title/Abstract] OR "Policy Advice"[Title/Abstract]))) AND Open Science	PubMed	10	21 Nov 2019
(Abstract:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (Abstract:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice")) AND Participat*	PubMed	0	29 Nov 2019
(TitleCombined:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (TitleCombined:("Knowledge Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice")) AND Participat*	PubMed	0	29 Nov 2019
((((TitleCombined:("Uptake of Open Science")) OR (TitleCombined:("Impact of Open Science")) OR (TitleCombined:("Reception of Open Science")))) OR (Abstract:("Uptake of Open Science" OR "Impact of Open Science")) OR "Reception of Open Science")) OR (SubjectTerms:("Uptake of Open Science" OR "Impact of Open Science")) OR "Reception of Open Science")))	TU Graz Library Search	9	10 Jan 2020
((Title Combined:("Policy Making" OR "Policy Design" OR "Policy Development" OR "Policy Maker*")) AND (Title Combined:("Knowledge	GoogleScholar	495	16 Jan 2020

Transfer" OR "Knowledge Exchange" OR "Policy Gap" OR "Policy Advice" OR "Research Utilization"))) AND ("Open Science" OR "			

Table 3: Overview of Search Strings

6.2 Survey and Interview Instruments

For most questions, we plan to use five-point-Likert scales. Survey items will be developed in English.

6.2.1 Groups of Questions (Item Batteries)

- Nationality, Organization, Role within Organization (Respondent Demographics)
- Open Science
  - Familiarity
  - National Open Science Strategies
  - Open Access, FAIR Data etc.
  - Attitudes towards Open Science Outputs
- Policymakers' information-seeking strategies
  - Information seeking
    - Communication/consultation within own networks
    - Literature search (university library, national libraries, parliament's library, parliamentary information services)
    - Internet research (newspapers, social media, blogs)
  - Consultation of experts
    - Who is contacted? How are informants identified/chosen?
    - Why are informants contacted? What's a typical situation where experts are contacted?
    - How are experts contacted and by whom?
      - Written communication/oral communication
      - Formal/informal
    - What is the purpose of expert advice (reduce ambiguity/reduce uncertainty?)?
    - The role of public consultations
      - Which members of the general public are contacted?
      - How?
      - For what purpose?
  - Access to scientific outputs
    - Publications: Reading habits
    - Data
      - Do policymakers use scientific data?
      - Under what circumstances?
      - How do they look for data and where?
      - How do they access data?
      - What do they do with scientific data?

- ▪ Other Outputs (blog posts, Social Media, etc.)
  - o Information Infrastructures (Kind, purpose, use)
  - o Personal information-seeking skills
  - o Government-commissioned Research (Why, how, for what purpose, published/unpublished)
  - o Role of Knowledge Brokers and institutional policy advice
    - ▪ Long-term standing advisory boards (e.g. parliamentary Technology Assessment Offices, Ethics Advisory Boards/Committees etc.)
    - ▪ Legal Basis/Applicable Legislature
    - ▪ Function/Process
      - • When?
      - • How?
      - • Why?
      - • For what purpose?

6.2.2 Example questions

- • Please rate the source of information that you find most relevant for your (parliamentarian, ministerial) work on a five-point scale (not relevant – highly relevant):
  - o Scientific literature
  - o Policy documents: EU, OECD, WHO, national sources
  - o Personal contacts
  - o Governmental advisory boards
  - o Other:
- • In your opinion, what is the quickest way to obtain relevant knowledge?
- • In terms of informants, who would you ask first, who would you ask second for scientific information?
- • Which of the following services are relevant for your work?
  - o Library (which one)
  - o Scientific Service (at parliament)
  - o Governmental agencies (e.g. Umweltbundesamt, TAB)
  - o Governmental advisory boards (Oberster Sanitätsrat, …)
  - o Other National Governments and Ministries
- • Are there ways in which you display the knowledge basis used for national policy making (e.g. ministerial websites, …) [Accountability question]
- • Are there (national) strategies to turn scientific studies commissioned by you into open access documents? Is there a national OA policy in place (specify link)?
- • What kinds of (scientific) information would you say are most useful to your line of work? Why?
- • What skills would you say are most helpful in terms of locating relevant scientific information?
- • How often do you read work published in peer-reviewed scientific journals?
- • How often do you have trouble accessing scientific content (problems of access)?