The Future of Science Governance: Publics, Policies, Practices

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Abstract

In this paper we develop new insights on science governance at a time when an emphasis on public engagement in responding to questions of trust in science is giving way to a more systemic and networked perspective. In a meta-analysis across 17 UK public dialogue processes we identify five spheres of public concern about the governance of science and technology relating to: the purposes of science; trust; inclusion; speed and direction of innovation; and equity. 40 in-depth interviews with senior UK science-policy actors reveal highly partial institutional responses to these concerns and help explain the underlying processes that close down, and at times open up, reflection and response on public values. Finally, we consider the implications of this analysis for the future of science governance, prospects for more anticipatory, reflexive and inclusive forms of governing, and the roles for critical social science inquiry.

Keywords: Science governance, public dialogue, public concerns, models of engagement, institutional responses, reflexivity

1. Introduction

Science and technology have, without doubt, a remarkable potential to disrupt societies, cultures, politics and the environment. This situation is highly ambiguous in environment and risk domains where science is (often simultaneously) presented as the cause, means of detection, and possible solution to pressing global problems and human needs. The governance of science itself has evolved over the last few decades to begin to accommodate some of the public concerns that reflect this disruptive power. Yet science governance struggles continually to be adaptive and responsive to public values, to the social and ethical impacts of science, and to the inherent complexity and uncertainty of natural and social systems in late modernity (Beck, 2000; Felt and Wynne, 2007; Funtowicz and Ravetz, 1993). Such difficulties are exemplified by high profile controversies ranging from resistance to emerging technologies such as genetically modified crops in the 1990s through to recent public questioning of climate science and the 'Climategate' affair.

A dominant institutional response to these challenges, and to associated questions of public trust in science, has been to open up governance processes and practices to a wider and more inclusive range of public inputs, notably through the creation of new spaces of 'public dialogue' (Bulkeley and Mol, 2003; Chilvers, 2008; Irwin, 2006). Central to this 'new' scientific governance has been the rush to develop, design, market and professionalise methods and techniques of public engagement and their evaluation (see, for example, Rowe and Frewer, 2000; Beierle and Konisky, 2001). In response to an emerging orthodoxy, critical public engagement studies have begun to problematise the ways in which public dialogue has

been enacted and the effects it has produced (see Chilvers, 2009). Attention has been drawn to, inter alia: the uneasy alliance between 'inclusive' governance approaches and traditional appeals to 'sound science' and expertise (Hagendijk, 2004; Irwin, 2006); framing effects within dialogue processes which can reinforce existing relations of professional power and deficit understandings of the public (Wynne, 2006); and analysis on how engagement processes construct particular kinds of publics that respond to contingent political imaginaries (Lezaun and Soneryd, 2007; Macnaghten and Guivant, 2011; Michael and Brown, 2005). Notwithstanding the importance of these studies, this paper makes four distinctive contributions aimed at notable absences in the literature.

First, there has been a lack of scrutiny on the distinctive ways in which institutional programmes of public engagement have linked to policy processes and institutional responses. Evaluation technologies tend to develop universal standards and modes of critique, predominantly linked to process criteria, yet engagement processes are developed in particular historical circumstances to respond to distinctive policy questions. In Section 2 we develop a typology of three ideal-type models of public engagement, and analyse how these were used across 17 public dialogues on science and technology that have taken place in the British context, on issues ranging from nanotechnology and stem cell research to the use of DNA in forensics and geoengineering of climate change. Using this typology we are able to examine the characteristic features of each, including their linkage to policy outcomes, the ways in which they construct subject positions and their staging in the innovation process.

Second, while public engagement processes are seen as significant sites for the democratisation of science, there has been a lack of attention to the substance of public concerns that emerge from them and their implications for governance. Analyses of what publics are concerned about and why are almost always limited to views on specific technologies. Comparative perspectives across different areas of science and innovation are virtually entirely missing from the literature. In order to address this gap in Section 3 we present one of the first meta-analyses of public concerns emerging across the 17 public dialogues on science and technology. In doing this we distil five cross-cutting public concerns evident in these dialogues that are fundamentally synoptic concerns about the governance of science and technology.

Third, existing social scientific analyses of institutional responses to public dialogues have for the most part tended to 'black box' institutions, or have led to general calls for institutional redesign (although see Bickerstaff et al, 2010). In Section 4 our empirical analysis moves beyond this to assess the ways in which science and policy institutions are responsive to the public concerns identified in our meta-analysis of public dialogues. We develop in particular a deeper understanding of the processes that underlie, constrain and mediate these responses. Our analysis is based on in-depth interviews with 40 senior staff from within UK science and policy institutions carried out in early 2011.

Fourth, in our concluding section we set out a prospective agenda for the future of science governance, taking into account our research and analysis coupled with a recognition that formal invited public engagements are only one of many routes through which public issues can be articulated and public values accounted for in the governance of science. Indeed, we advocate the need to move from viewing public engagement as an end in itself towards a broader appreciation of the science governance system as a whole. In adopting this systemic perspective we consider what it means to develop anticipatory, reflexive and inclusive forms of governing in the public interest.

2. Models of Science Governance

2.1 The Sciencewise Expert Resource Centre

In the UK, the Sciencewise Expert Resource Centre (or Sciencewise-ERC), funded by the Department for Business, Innovation and Skills, has been an integral part of scientific governance, commissioning and championing public dialogue since 2004. Its birth followed the demise of the CoPUS Grants Committee, a funding body administered by the Royal Society and charged with bringing scientific issues to the attention of the wider community and promoting a more scientifically literate society. The idioms of CoPUS lay in one-way forms of science communication and deficit models of public understanding. In its place, Sciencewise (renamed Sciencewise-ERC after 2007) spoke to the new discourse of two-way dialogue and public engagement (on the 'new scientific governance', see Irwin, 2006).

In substantive terms, Sciencewise-ERC has constructed and guided a number of dialogue projects which aim to open up the competing values, ethics, issues and interests associated with new science and technology, to provide social intelligence to policy-makers, and to help inform choices and trajectories. The Sciencewise-ERC has in addition fulfilled a normative role in encouraging the appetite for public dialogue within government and its agencies, through the provision of opportunities for training and networking, and through guidance on best practice. The Sciencewise-ERC thus can be seen as a central pillar in the UK Government's ambitions for a society in which the public, the broad science community and policy makers feel comfortable with the direction taken by science and technology.

2.2 Three models of dialogue

The 17 dialogue projects that Sciencewise-ERC has co-sponsored since 2005 (and up to December 2010 when the research took place) have been designed to cover a wide range of issues associated with novel science and technology but also to inform policy processes. In our research, we developed a coding strategy to describe the different ways in which public dialogue was envisaged in these projects. Partly, we adopted a grounded theory bottom-up approach based on a close reading of reports from the 17 dialogue events as published on the Sciencewise-ERC website (see sciencewise-erc.org.uk/cms/dialogue-projects). Partly, we adopted and extended a set of distinctions developed by Roger Pielke (2007) on the different ways in which scientific advice can inform the policy process. Whereas Pielke's approach is concerned with the different roles of the scientist in decision-making our concern lay with the demarcation of different models of public engagement. Whereas Pielke's typology includes four ideal types – the 'pure scientist', the 'science arbiter', the 'issue advocate' and the 'honest broker' – our analysis extended this typology to include an 'Upstream' model of public engagement. The three models of engagement derived – namely the 'Upstream' model, 'Honest Broker' model, and 'Issue Advocate' model – are summarised in Table 1 and described in the remainder of this section.

Table 1. Three models of public engagement in policy-making

	Public Engagement Processes

Model of Public Engagement	*Stage in Innovation Process*	*Link to Policy Outcome*	*Topic of discussion*	*Subject Position*	*Status of Policy Goal*
Upstream Model	Early	Vague	Possible worlds	Exploratory subjects	Emergent
Honest Broker Model	Mid-stream/ downstream	Strong	Known worlds	Reflective subjects	Ambivalent
Issue Advocate Model	Mid-stream/ down-stream	Strong	Known worlds	Malleable subjects	Predetermined

The 'Upstream' model of public engagement (Table 1) became established in dialogues where the objective was to engage publics in exploratory conversations on a range of issues and questions posed by science and technology at a relatively early stage in the innovation process. The focus of these dialogues was on scrutinizing the ways in which the emerging science and technology is imagined by social actors, exploring future possible worlds, the social and ethical issues associated with them, and deliberating on the factors that shape public concern, hope and possibility. Such dialogue events were tied loosely to specific policy goals and outcomes with participants being constructed as 'exploratory subjects' who developed novel identities and positions through the dialogue itself. In our coding analysis each of the 17 dialogue processes were attributed to one or more model of public engagement, as presented below in Table 2 (below). This shows the dialogues that took on the 'Upstream' model to include those on specific areas of emergent science and technology (*Synthetic Biology*, *Nanodialogues*, *Industrial Biotechnology*, *Geoengineering*), as well as projects that explored possible future directions in science in general (*Science Horizons*, *Community X-Change*).

The 'Honest Broker' model of public engagement (Table 1) was enacted in dialogues where the articulation of different policy options associated with a particular branch of science was already mature and social/ethical dilemmas already apparent. In these dialogues, which had closer links to policy outcomes and were less exploratory, the overriding aim was to foster public deliberation in weighing up of the pros and costs of different courses of action, as well as the articulation of the conditions, if any, under which different policy options were seen as acceptable. These dialogues tended to position publics as 'reflective' subjects who contemplate the conditions of whether and how to proceed with a controversial domain of science. As shown in Table 2 (below) the 'Honest Broker' model was favoured for health-related questions, where the aim was one of helping sponsors to determine whether, and under what conditions, to fund and move forward with specific and ethically-challenging research (*Animals containing Human Material*, *Hybrids and Chimeras*, *Stem Cells*). Other dialogues adhering to this model centred on possible scientific developments in the use of drugs for human enhancement (*Drugsfutures*), those that pose new dilemmas for the use and management of information (*Forensic Use of DNA*), through to deliberation on values, benefits and trade-offs in relation to future land use scenarios in the context of climate change (*Landscape and Ecosystem Futures*).

The 'Issue Advocate' model of public engagement (Table 1) became established in dialogues where there existed an already formed and agreed policy goal. The function of such dialogues was not to deliberate on these goals but rather on the conditions under which they could be realized and the different ways of achieving them through better understanding the views, beliefs and needs of publics. There was much less scope to the explore the framing of policy goals and discuss alternatives, which meant that publics were most often assumed to

be ‘malleable’ subjects able to bend their views and positions through the provision of information and argument by the sponsoring institution. As shown in Table 2, this ‘Issue Advocate’ model was common in dialogues on climate change, responding to the policy goal of stimulating behaviour change as part of the UK Government’s commitment to legally binding target of at least an 80% cut in greenhouse gas emissions by 2050. Policy-derived questions shaping the various dialogues included: how to cut emissions at a local level (*Low Carbon Communities Challenge*), how to encourage people to change their energy behaviour (*The Big Energy Shift*), how to engage representatives of the public in local communities across the UK to run local deliberative dialogues (*Energy 2050 Pathways*), how to increase awareness in students aged fourteen and over of issues of risk in science (*Risky Business*), and on how to improve cyber trust (*Trustguide*).

Table 2. Sciencewise-ERC dialogue activity by model of public engagement

Dialogue Project	*Model of Public Engagement*		
	Upstream	*Honest Broker*	*Issue Advocate*
Animals containing human material (2010)		✓	
Big energy shift (2008–2009)			✓
Community X-Change (2005–2008)	✓		✓
Drugsfutures (2006–2008)		✓	
Energy 2050 pathways (2010–2011)			✓
Forensic use of DNA (2007–2008)		✓	
Geoengineering (2010)	✓	✓	
Hybrids and chimeras (2006)		✓	
Industrial biotechnology (2008)	✓		✓
Landscape and ecosystem futures (2011–)		✓	
Nanodialogues (2005–2007)	✓		
Low carbon communities challenge (2010–2011)			✓
Risky business (2005–2006)			✓
Science horizons (2006–2007)	✓		
Stem cells (2007–2008)		✓	
Synthetic biology (2009–2010)	✓		
Trustguide (2005–2006)			✓

The three models of engagement identified in this section are ideal types. It is clear that in practice any one individual dialogue event may subscribe to more than one of these models. For example, as shown in Table 2, ‘Upstream’ dialogues on *Industrial Biotechnology* and *Community X-Change* also took on aspects of the ‘Issue Advocate’ model, while the *Geoengineering* dialogue overlapped with the ‘Honest Broker’ model. The three models of engagement do nevertheless serve as a useful heuristic to reveal the different functions of public dialogue in the policy process.

3. A Meta-analysis of Public Concerns

As noted above, there has been little attention drawn to the common issues of concern that have emerged across public dialogue initiatives and of their cumulative significance for questions of governance (although see Start, 2010). In this section we analyse key cross-cutting themes shared across the Sciencewise-ERC dialogues. Again, the analysis is based on

a thematic coding of concerns as presented in published reports of the 17 dialogue events. Across the dialogues, five cross-cutting themes were found to be central to the structuring of public responses, and are discussed below.

A key factor shaping people's attitudes towards science and technology concerned their assessment of the *purpose* of the science, and of the motivations of those involved. In whose interests was the science being developed? Were particular innovations necessary? Were there alternatives? Medical and health technologies were seen by and large as driven by good purposes, including that of curing diseases, improving wellbeing and prolonging life. Research was thus accorded high importance, even when there were acknowledged ethical dilemmas. For these reasons, the public clearly appreciated their role as 'Honest Broker' in health-related dialogues (*Animals Containing Human Material*, *Hybrids and Chimeras*, *Stem Cells*), helping to determine whether, and under what conditions, to fund and move forward with specific and ethically-challenging research. In the *Stem Cells* dialogue, support for further advances in the science was seen as conditional on the purposes of the research and on whether it respects human values: Will it reflect public rather than solely commercial interests (pages 71–74)? Will it respect individual rights and autonomy (page 70–71)? Will it focus on serious diseases (pages 64–65)? Similarly, in the *Animals Containing Human Material* dialogue, support was similarly premised on the assumption that the aims of the research would be to improve human health or cure human diseases (page 21). For 'Upstream' dialogues (*Science Horizons*, *Synthetic Biology*, *Nanodialogues*, *Industrial Biotechnology*), the question of the purposes to which science would be directed was also a central issue. In the *Synthetic Biology* dialogue, for example, the motivations of scientists were deemed to be a key determinant for assuring acceptability. Five questions were seen as central to public concerns: "What is the purpose of your research? Why are you doing it? What are you going to gain? What else will it do? How do you know you are right?" (page 85) Given that the science was at an early stage, with clear potential for good and bad, ensuring that the science would be conducted for good reasons (i.e. in response to societal needs rather than for short-term gain or for knowledge for its own sake) was viewed as critical.

Trust was a pervasive feature shared across a number of dialogue projects: people rarely trusted the motives of Government to act in the public interest. This general mistrust was prominent in 'Upstream' dialogues (*Synthetic Biology*, *Nanodialogues*, *Industrial Biotechnology*), where even at an early stage of research, the direction being undertaken by science was seen as in danger of being overly directed by private rather than public interests. This distrust was apparent especially in domains where there was a perceived proximity between government and industry, most notably in agricultural and industrial biotechnology. As the report on the *Industrial Biotechnology* dialogue states: "Profit or anything associated with industry are viewed with great suspicion and there is little faith that the Government will effectively resource the control and monitor[ing of] industry" (page 4). Indeed, while the motives of scientists may be trusted, in general, the motives of government and industry were not. As Start comments in his review: "The initial public perception of government is of a regulatory structure that is weak and unreliable, vulnerable to private interests, and vulnerable to dangerous products slipping through the net" (Start, 2010, page 20). Trust was also an issue in 'Issue Advocate' dialogues, notably on climate change issues where the science was presented as being conducted for good purposes (e.g. to save the planet) and where these claims were often disputed by lay participants. In the *Big Energy Shift* dialogue, for example, participants expressed a lack of trust that either the Government, or the private

sector, would actually deliver a fair and equitable system to respond to climate change (page 24). In the 'Honest Broker' *Geoengineering* dialogue, there was similar mistrust expressed in the accuracy and robustness of climate models and projections, and in the extent to which scientific research could ever truly be independent of the interests and agendas of funding agencies (page 67). The notable exception was in health-related *Honest Broker* dialogues where, alternatively, there was an underlying sense of trust and confidence in regulation, oversight and in the good intentions of Government (*Animals containing Human Material, Hybrids and Chimeras, Stem Cells*).

In a project on public perceptions and sustainability, Macnaghten and Jacobs (1997) observed that the pronounced fatalism and cynicism that people expressed towards national and local government was a key barrier to environmental behaviour change. It was further argued that attempts by government to galvanise community action would depend on their ability to develop relational mechanisms through which a sense of *inclusion* and shared purpose could be established. 10–15 years later, and despite a heightened institutional rhetoric on inclusion, it is clear that many people still feel they are not included in deciding what kinds of public science and technology gets funded and for whose interests: i.e. they feel 'kept in the dark'. This sense of powerlessness was especially developed in the *Synthetic Biology* dialogue, where there was a strong sense that scientists were a closed community that was difficult to gain access, where technical expertise set scientists apart from the public, and where it was believed there was a cultural resistance to opening up science to the views and values of the public (page 41). This was particularly problematic as participants felt compelled to trust scientists, but ultimately felt powerless to have any control. Similar views were evident in other 'Upstream' and 'Issue Advocate' dialogues: in the *Industrial Biotechnology* dialogue participants expressed a sense of disaffection from the scientific and industrial process (pages 21–22); in the *Big Energy Shift* dialogue, people saw themselves as relatively powerless in promoting behaviour change, with a sensed lack of leadership and overall narrative from Government (pages 20–22); and in the *Nanodialogues* people felt similarly disaffected, as indicated in some of the dialogues, where one participant commented, tongue in cheek, on the peculiarity of the dialogue process: "I feel lucky, I feel like we can make some nanoscule contribution to society" (page 12). While participants expressed a sense of powerlessness across all models of dialogue activity, across the 'Upstream' dialogues powerlessness tended to be expressed as fatalism (an attitude of resignation in the face of a political economy of science that they have minimal power to shape), in the 'Issue Advocate' dialogues powerlessness was more likely to be expressed as scepticism (an attitude of doubt to the apparent claims and interests of official institutions), while in the 'Honest Broker' dialogues, powerlessness tended to be an issue only so far as public interest criteria were seen as unlikely to inform policy decisions.

A long-standing public concern is that research and innovation processes are being developed at a *speed* that exceeds their scope for ethical and regulatory oversight (for an academic treatment of speed, see Bingham, 2008; Stengers, 2000). Examples of this kind of concern can be seen in the *Stem Cells* dialogue, about "research being pushed to deliver applications too soon", (page v), and in the *Synthetic Biology* dialogue, about the dangers of "speeding up nature" (page 83). As can be seen from the examples above there were two variants. In the 'Honest Broker' dialogues this concern tended to be expressed through the danger of short-term commercial pressures trumping social and ethical considerations, while in the 'Upstream' dialogues this concern was expressed more ontologically, in relation to the power of emergent science to disrupt and mess with natural orders and processes (for an

extension of this argument, see Macnaghten, 2010). Concerns were also voiced on the *direction* science is taking us, and whether this has been adequately considered and deliberated upon in advance (see also Stirling, 2008; Stirling and Mayer, 2001). These concerns, chiefly manifest in the 'Upstream' dialogues, extend beyond matters of safety and technical risk to a broader set of social and ethical issues that included: concerns over unforeseen consequences including controllability and reversibility (*Geoengineering,* pages 2–4; *Synthetic Biology*, pages 71–72), impacts on perceived naturalness (*Geoengineering,* pages 32–33; *Synthetic Biology*, pages 39–40); and impacts in terms of fairness and equity (*Geoengineering*, pages 58–59). As the *Nanodialogues* report commented: "Safety was a sideshow. The real concern was with where companies are taking us" (page 63). The analysis undertaken in the summary reporting of the *Science Horizons* dialogue is insightful in articulating the direction to be taken by science. Future science and technology were viewed as acceptable to the extent to which they respond to 'social goods', namely: better health (a social good); independence, especially for the elderly (a social good), convenience (a social good), quality of life (a social good), risks to safety (a social bad), scope for loss of privacy and autonomy (a social bad), social divisiveness (a social bad) and lack of genuine human interaction (a social bad) (pages 6–7). While each of the above points requires further differentiation and expansion, it nevertheless reinforces the observation that public views on science and technology depend critically on their 'social constitution', that is on the distinctive values and social assumptions that are embedded in their development (Grove-White et al, 2000).

A final theme concerns lay *ethical* judgement. A primary consideration was whether there is a sense of genuine social benefit from publicly funded science. At an individual level, where the social benefit was high, the public were prepared to accept higher trade-offs. Thus, in the *Stem Cell* dialogue, stem cell research was seen as acceptable only in cases where there existed the potential for very significant medical breakthroughs for the treatment of incurable diseases. In cases where stem cells were proposed in cosmetic applications or for the purposes of human enhancement, where the social benefit was seen as low, the research was seen as less acceptable (page 26). This kind of trade-off is commonplace in the 'Honest Broker' dialogues. A subsidiary consideration was the social distribution of those costs and benefits. Across many of the dialogues was a concern that the political economy of new science and technology will disproportionally impact upon vulnerable groups, particularly the poor, the ill, the unborn and those unable to defend themselves. Concern was expressed that nanotechnologies would benefit the rich and the powerful, not the poor or the unemployed (*Nanodialogues*, page 38); that medical research will be biased towards western and affluent illnesses rather than those in developing countries (*Stem Cells*, page 28); that the National DNA database can be used by governments to further discriminate against ethnic minorities *(Forensic Uses of DNA*, page 55); while the use of new drug treatments in the management of mental health conditions can be seen as a cheap alternative to social and behavioural therapy (*Drugsfutures*, page 35). This kind of consideration is again most common in the 'Honest Broker' dialogues. A final consideration was the differing and competing philosophical perspectives that people used to discuss the ethics of particular scientific and technological innovations. Start (2010) distinguishes two competing philosophies at work in the dialogues: a liberal and individualistic set of values and rights pitted against communitarian and collective values and virtues. Thus, while people were in general positive about the prospects of new technology to improve convenience, save time and add choice (appealing to liberal and individualistic values), at the same time they were wary that those same technologies will erode communities, devalue traditions, and dehumanize relationships (*Science Horizons*,

pages 6–7). While there was strong concern about the perils of inappropriate drug use from a collective viewpoint, there was at the same time strong support for individuals to have the right to make their own decisions (*DrugFutures*, pages 46–52). While there was strong support for the use of science and technology to aid national security, publics also spoke up for rights to privacy and anonymity *(Forensic Uses of DNA*, pages 34–36).

Even though there was considerable overlap between and across the public dialogues we can still however identify clear affinities between the kinds of concerns expressed by publics and the three models of public engagement identified in our typology above. These relationships are summarised in Table 3 below. It shows how concerns for 'Upstream' dialogues tended to be more oriented towards the motivations of scientists and funding bodies and whether such science was responsive to collective values and respectful to natural orders. For 'Honest Broker' dialogues, where the good intentions of policy-making bodies tended to be more assured, concern focused on whether ethical and social considerations would genuinely inform decisions in the face of over-riding commercial pressures. While in the 'Issue Advocate' model, the emphasis of concerns was on the legitimacy of the pre-determined policy goals and their responsiveness to public input.

Table 3. Public concerns across three models of public engagement

	Public Concerns about Science Governance				
Model of Public Engagement	*Purposes*	*Trust*	*Inclusion*	*Speed and direction*	*Ethics, trade-offs and equity*
Upstream Model	Were the motivations of scientists good and transparent?	Were funding bodies directing research to the public interest?	Would public input have the power to shape science's political economy?	Would the science respond to 'social goods'? Would it respect natural orders?	Would individual and market-driven values over-ride collective values?
Honest Broker Model	Did the research demonstrate respect to basic human values?	Were science and funding bodies independent of interests?	Would social and ethical values genuinely inform policy deliberation?	Would short-term corporate pressures over-ride social/ ethical considerations?	Would the impact of the science unfairly impact on vulnerable groups?
Issue Advocate Model	Were the pre-determined goals of policy legitimate and plausible?	Were policy institutions to be trusted in pursuing their stated intentions?	Were the goals of policy institutions open to challenge by public input	Would corporate pressures direct science at the expense of social/ ethical considerations?	Was the social benefit promised by the science sufficient to over-ride unreflected social/ ethical considerations?

4. Institutional Responses

We now assess the extent to which UK science and policy institutions have been responsive to the substantive public concerns about science governance identified in Section 3. The analysis is based on evidence from 40 in-depth interviews with senior staff from 23 UK-based science organisations.[1] Given the sensitive nature of the interviews, and to encourage

[1] All interviews were conducted between January and March 2011 and lasted between half-an-hour and one hour. Typically two interviews were conducted per organisation, mostly with senior decision-makers (for

respondents to be candid and open in their responses, the use of verbatim quotes was not explicitly sought. Interview transcripts were subject to full qualitative coding analysis in order to establish the key conditions and processes that mediate institutional responses. Mediating influences were established through a grounded analysis of interviewees' talk in conjunction with explanations drawn from the literature. These analytic coding categories are now presented by taking each of the five main areas of public concern in turn whilst paying attention to the different organisational settings of the interviewees (see Table 4).

Table 4. The distribution of interviewees in relation to organisation type

Organisation type	**Number of organisations**	**Number of interviewees**
Government departments	4	9
Science funders	4	8
Regulators	4	8
Other government agencies (including local government)	4	5
Businesses (those involved in technology transfer)	4	5
Learned Societies	2	4
Non-governmental organisations	1	1
Total	*23*	*40*

The majority of interview respondents did not recognise public concerns associated with the *purposes* of science. Across all organisational contexts the good purpose of science was automatically assumed and presented as self-evident. Respondents found it difficult to relate individual research projects and programmes to outcomes of limited public value. For example, agricultural biotechnologies, which are often viewed by publics as offering less benefits and more impacts to society that healthcare technologies say, were seen as serving the public good, particularly in relation to future food security. This dominant institutional response is largely out of step with the public concerns presented in Section 3 and identified as an important source for public unease (for variants of this argument see Marris et al, 2001; Kearnes and Wynne, 2009; Macnaghten et al, 2005). Widespread social concerns over the underlying motives of environmental and agricultural technological developments, for example, were simply dismissed by some interview respondents as that of 'a small number of vocal people'. While there are many possible explanations for this lack of institutional reflection, a key aspect identified in interviews was the prevalence of unreflexive science-policy cultures and the predominance of technocratic organizational structures, which previous studies have shown to be a dominant characteristic of British science institutions (Wynne, 1993; Irwin, 1995). The governance structures within most organisations were dominated by experts and specialists. Technical or policy expertise remained at the forefront of decision-making. And the science-centred vision of those leading these organisations determined decision-making processes. Organisational structures, embedded in deeply rooted science-policy cultures, appeared to be closing down institutional reflection on the

example, the Chair, CEO, Director of Strategy/Policy, or senior civil servant). 38 in-depth interviews were conducted over telephone, one interview was conducted face-to-face, and one via email correspondence (due to limited availability of the respondent). Interviews were audio recorded and transcribed for analytical purposes (for further details see TNS-BMRB, 2011)

conditions, framings and pre-commitments that were shaping science and innovation practices (Wynne, 1993). For example, in interviews respondents reflected very little on the possibility that wealth creation priorities may act to influence individuals to focus on short-term gain rather than long-term public interest.

Public concerns relating to *trust* in government were more readily acknowledged by interview respondents. Close relationships between public funded research and private interests were recognised as impacting on institutional trust. The dominant response from most interviewees was to presume that these ambiguities could be managed through commitments to openness and transparency. This was of particular importance for regulators and government departments (through opening up access to meetings and advisory committees, for example) and to research funders (where open data had become an increasing priority in the wake of Climategate). Interviewees spoke of oversight and organisational practices, such as time limits on the management of individual research portfolios and judicial review procedures. Some interviewees in addition placed emphasis on promoting 'trustworthy behaviours', by valuing openness, listening skills, keeping commitments and being willing to admit doubt. At another point in the interview schedule, when reflecting on the key strategic issues shaping science governance, many respondents highlighted the coupling of research with wealth creation and the increasing commercialization of science, which others have identified as key 'driving forces' shaping science governance (e.g. Felt and Wynne, 2007; Pestre, 2008). This was seen to be driving closer collaboration with business, commercialization of research, developments in knowledge transfer, the impact agenda, and so on. Yet the possible connection between these driving forces and questions of institutional trust was recognized as a source of tension by interviewees across all organizational settings. These complex issues of trust, then, were predominantly recognised as being tractable in a procedural sense rather than more structural in nature (see Wynne, 2006). Responses did not extend to addressing deeper public concerns evident across the Sciencewise-ERC dialogues over the increasing role of private interests in directing science and the need for science to address questions of the common good (see Felt and Wynne, 2007).

All respondents recognised public feelings of powerlessness and the need for *inclusive* governance processes. Most noted existing attempts to address these concerns through forms of public dialogue. Dialogue processes that had clear goals and a clear decision context were cited as having most impact on policy in this regard. However, more generally, public engagement activities were seen to have had marginal impact on core business, with key messages often being externalised by organisations at the expense of prompting internal institutional reflection. Most respondents saw a limited role for active public involvement in organisational decision-making (such as over science funding decisions) but emphasised the need to feed in public views at strategic levels of science policy and the overall direction of travel. While this indicates receptiveness to upstream models of engagement (Wilsdon and Willis, 2004) the dominant rationale for this expressed in interviews was one of technological acceptance rather than ensuring that public values substantively shape the purposes, speed and direction of science, exposing a dominant instrumental tendency also identified in other analyses (see Stirling, 2008). Organisations where public engagement had produced more impact on decision-making generally had a supportive CEO, a decentralised decision-making culture, a culture of risk taking, and an appetite to embed focused engagement activity in policy departments rather than communications or science in society directorates. At the time of interviews in 2011 a major dynamic was the global recession and widespread economic constraints, which was writ large in discussions of powerlessness and inclusion. Most organisations had begun focusing on 'core business'. Budget cuts and changing Government priorities were creating pressures to close down deliberation and public engagement

activities. Economic constraints were however seen by some interviewees as an opportunity, offering potentials for interdisciplinary and collaborative practices, and new routes through which public values can be accounted for in the governance of science. This illustrates how agencements that are often simplistically assumed to be forces of closure can simultaneously act as sites of emergence and 'overflow' (Callon et al, 2007).

When considering the *speed* of research and innovation processes there was widespread acknowledgement that regulation generally lags behind innovation. Some respondents questioned the premise of this public concern however — specifically whether technologies by definition move on at such a pace that inhibits oversight. Any such 'lag' was put down to science and policy institutions paying insufficient attention to developments as they are progressing and failing to create adequate space for discussion of the implications of technological developments. Representatives of regulators themselves admitted that their attention was predominantly focused on the 'here and now'. One respondent noted that 'we can only regulate what's out there'. This narrowed the focus of regulators on to downstream risks and impacts rather than exploring the human needs and purposes that drive science (see Macnaghten et al, 2005). *Directionality* of science and technological development (Leach et al, 2010) was not seen as a major issue for reflection, in much the same way as the above discussion of purposes.

With respect to *ethics, trade-offs and inequity* all interview respondents were asked to reflect on whether the culture of science discourages scientists from reflecting on the ethical considerations and uncertainties inherent in forms of science and innovation. While ethical reflection was not emphasised as much in interviews, there was a general feeling that scientific cultures and practices had become more open and prepared to admit uncertainties. Organisational cultures (see also Argyris and Schön, 1996; Fletcher, 2008; Guy, 2006; Schein, 1995) were highlighted as being crucial in mediating this. For example closed cultures were seen to create an ethical distance between scientists and societal interests and to lead to the normalisation of ethically sensitive activities. Amongst organisations that provide leadership to the scientific community (such as learned societies and research councils) there was an effort to help create a 'climate of recognition' through awards, structures, and statements of principles for scientists to engage or act ethically. In reflecting on these issues some respondents noted that the UK Government's spending review and wider commercial drivers were not helping scientists to reflect openly on their work. Rather, they encouraged institutions to demonstrate the economic value of research, through a language of success and growth: making it difficult for researchers to be seen to detract from overriding purposes of science-led progress (see also Irwin, 2006).

In sum, the reflections of interviewees and the stated responses of UK science and policy institutions only partially addressed, and in some cases dismissed, the five main public concerns about the governance of science identified in our analysis of the Sciencewise-ERC dialogues. Concerns over the purposes and direction of science and innovation were largely denied by institutional actors in interview, while public concerns about trust, powerlessness and the speed of scientific innovation where acknowledged and responded to in a procedural or instrumental fashion thus side-stepping some of the underlying tensions and sources of public unease.

The analysis in this section has provided insights into the underlying processes and key mediating influences that help explain institutional responses, as identified in interviews and in connection to existing literatures. These themes are synthesized in Table 5, namely: science-policy cultures, organisational structures/cultures, leadership, the economic climate, commitments to economic progress, and openness and transparency. The dominant dynamic across the institutional settings discussed by respondents has been for these influences to

close down reflection on public values and concerns about the governance of science and technology (as shown in the left-hand column of Figure 4). However, it is also clear that these same mediating factors have, in some instances but to a much lesser degree, prompted reflexive openings within institutions and science governance (see the right-hand column of Table 5).[2] Taken as a whole, the grounded perspectives of institutional actors offer new insights on the patterning of institutional responses to stated public concerns about the governance of science.

Table 5. Key influences on institutional reflection and accountability in relation to public concerns about the governance of science and technology.

Mediating factor	**Potential to close down reflection on public values**	**Potential to open up reflection on public values**
Science-policy culture	Expert-led structures and routines can privilege scientific rationality to the exclusion of other perspectives (including publics)	Deliberative cultures can emphasise reflexive learning and responsiveness to other perspectives (including publics).
Organisational structure/culture	Centralised, elitist, inward looking, risk-averse science organisations can routinise closed ways of working and limit reflection	Innovative, creative, experimental and risk taking science organisations can foster a culture of openness and open scientific inquiry
Leadership	Technocratic leaders can resist change as they have considerable influence over the extent to which public values and the public interest are taken into account	Top-level leadership and commitment to public engagement can embed public engagement, culture change and taking account of the public interest
Economic climate	Economic constraints can lead to retrenchment and a focus on core business, limit public engagement, and close down the framing of problems	Economic constraints can promote collaboration and interdisciplinary working, and create new routes through which public values can be expressed
Economic/science-led progress (wealth creation)	The tight coupling of research and wealth creation places increasing emphasis on outcomes and the instrumental purposes of research, closing down reflection about wider public values	The tight coupling of research and wealth creation can generate possibilities for open innovation and experiments in reconfiguring relations between science, innovation and society
Openness and transparency	An instrumental, functional and procedural drive towards open access and transparency can undermine institutional potentials for listening to public values and social purposes.	Commitments to openness and transparency can form an essential part of an integrated organisational strategy for governing in the public interest

5. The Future of Science Governance

[2] Although much less evident across the dataset, all illustrations of how mediating influences might open up institutional reflection in the right-hand column of Table 5 were touched upon in at least one interview - apart from the theme of science-policy culture, the illustration for which is drawn exclusively from relevant literature (see Wynne, 1993; Felt and Wynne, 2007).

In the analysis presented above we highlighted five spheres of public concern that appear to be commonplace, that raise significant questions for the future governance of science, and that are being only partially addressed by UK science and policy institutions. We developed understandings of the mediating influences that shape institutional responses and of how these both constrain and, on occasions, open up reflection on public values. In the remaining discussion we draw across the different elements of our analysis to consider the implications for future science governance. In particular we argue for a more systemic perspective on science governance that moves beyond a focus on procedural or instrumental 'fixes' to build anticipatory and reflexive forms of governing in the public interest. We then outline a programme for a critical social science on the future of science governance.

5.1 Governing in the public interest

The Sciencewise-ERC dialogues have proved to be an important analytic resource in this paper in establishing cross-cutting public concerns about science governance. They also represent what has become a defining form of science governance practice over the past decade associated with a relative shift in emphasis from public understanding of science to public engagement with science and its subsequent 'upstreaming' in the UK and many other western democracies. The Sciencewise-ERC model of small group micro-invited public deliberation - or so called 'mini publics' - is a particular one in the wider public engagement landscape (see Chilvers, 2010). Yet in line with the need to attend to the construction and productive dimensions of new governance approaches (Irwin, 2006), we have shown in Section 2 how this seemingly narrow technology of participation has taken on different forms, constructed different subject positions and definitions of the issues at stake, at different stages of the innovation process.

Our analysis thus suggests a need for policy-makers, commissioning bodies and social scientists alike to engage more reflexively with what we have termed 'Upstream', 'Honest Broker' and 'Issue Advocate' models. For example, when it comes to upstream processes stated public concerns suggest a need for more deliberate consideration of political economic dimensions, the underlying motivations of science and scientists, and the potential for new science to disrupt natural orders. Honest broker type dialogues should show awareness of the framing effects and constraints on feeding public inputs into governance processes associated with more established policy issues. Whereas issue advocate engagement processes face the challenges of reflecting on and opening up deliberation to the pre-commitments that define policy goals and taken-for-granted assumptions about institutional responsibilities and trust. Notwithstanding these specific insights, an underlying message from the current analysis is the need for all three models of dialogue to be reflexively attentive to the conditions and processes that open up and constrain institutional responsiveness to the outputs of public dialogues (as outlined in Section 4).

Having said this, an important insight of our analysis is that efforts to deepen the role of public engagement in bringing about institutional reflection will not be straightforward, nor can innovations in public dialogue be regarded as a complete response to the challenges of governing complex and inherently uncertain areas of science and technology. That the stated public concerns identified in Section 3 were most often not acknowledged or being taken up in institutional responses identified in Section 4 shows that forces of closure were all too apparent. While the timing of our study during a period of economic downturn and austerity was an important influence, more durable forces of closure were also significant, not least ingrained science-policy cultures. In drawing across the elements of our analysis, it would be

wrong to simplistically read these findings in terms of the limited 'impact' or failed influence of public participation on science policy-making, as is so often the case in established evaluation criteria and frameworks (e.g. Rowe and Frewer, 2000; Beierle and Konisky, 2001). The reflections of interviewees in Section 4 instead highlight science governance as a complex interplay of multiple actors, intermediaries and other influences in a co-produced and interconnected system. Within this, rather than exclusively focusing on formal institutionalized spaces of public dialogue *per se* respondents spoke of many different routes through which public values can be heard and accounted for in science governance.

These reflections of interviewees concur with an evolving landscape of emerging innovations in science governance practice, some of which have been prompted by recent science controversies (see Chilvers and Macnaghten, 2011), including: new forms of citizen science and public engagement in science such as crowdsourcing, distributed innovation, and open source movements (see Ekins and Williams, 2010); novel science advisory structures with commitments to transparency and openness (see Grove-White, 2001); forms of self regulation and voluntary reporting for science and scientists (see European Commission, 2008); and increasing moves towards open data and open science, for example in areas implicated in recent controversies over climate science (see Kleiner, 2011). These emergent governance responses are indicative of a wider shift in institutional rhetoric and practice from a focus on public dialogue and engagement in responding to issues of public trust in science, towards a broader appreciation of the science governance system as a whole in which public engagement forms a specific and important part. However, while this shift is at times apparent, more readily it remains opaque within a myriad of initiatives and techniques that remain disjointed.

Recent scholarship has attempted to integrate such initiatives into a coherent conceptual framework. Predominantly within the nanotechnology domain these endeavours have aimed to develop models of upstream public engagement aimed at exploring the social and ethical implications much earlier on in the innovation process, when it is still possible to shape the development of the emerging technology (Macnaghten et al, 2005); to move the debate from a narrow focus on risk governance, where the questions are reduced to ones of risk and safety, to 'innovation governance' which emphasises 'upstream questions' of the sort routinely raised by publics in dialogues (Felt and Wynne, 2007); to develop new forms of ethical reflection and societal responsiveness within the scientific community (Fisher et al, 2006); and to integrate such elements within overarching frameworks of responsible innovation, anticipatory governance and real-time technology assessment (Barben et al, 2008; Guston and Sarewitz, 2002; von Schomberg 2011). Narratives and frameworks of responsible innovation have gained particular policy relevance in the last few years with initiatives being developed in the UK, Norway, the Netherlands and in particular the European Union, where Responsible Science and Innovation will feature as a cross-cutting issue under the 'Horizon 2020' programme (Owen et al. 2012 forthcoming; Stilgoe et al. 2012 forthcoming; von Schomberg 2012 forthcoming).

One danger inherent in current initiatives is that they may accommodate alternative governance arrangements in the form of a set of procedural arrangements, thus bracketing out reflection on the key mediating factors that structure institutional responses in real-world circumstances, as set out in Table 5. Without such recognition new science governance innovations may be reduced to a new wave of procedures that could become used by policymakers for instrumental ends. An alternative is to build on such initiatives to move towards an institutionally reflexive approach aimed at 'governing in the public interest'. Even though anticipation, adaptation, deliberation and reflexivity remain core dimensions and

frameworks for science governance, properly accounting for public values depends on reflexivity in a radical social relational sense and not just merely a procedural one.

Wynne (1993) defines reflexivity within the science governance system as a "process of identifying, and critically examining (thus rendering open to change), the basic, pre-analytic assumptions that frame knowledge-commitments" (page 324). In our analysis we found that it was precisely such self-reflective and relational forms of reflexivity that are routinely and systematically closed down by prevailing science-policy cultures, whether about the conditions that mediate science governance or about the diverse assemblages that constitute definitions of the public issues at stake. At a time of austerity and constraint, it becomes ever more urgent to reconfigure science governance in ways that set out to be deliberately reflexive; to imagine, prompt and shape transformative and reflexive forms of learning in science governance systems (Felt and Wynne, 2007; Chilvers, 2012).

5.2 Critical social science for science governance

The analysis presented in this paper raises challenges and opportunities for critical social science. There is the need for further research into the cross-cutting public concerns identified in this paper, which are not about reactions to particular technologies *per se* but rather how science in general is governed in real world circumstances. This raises complex analytical questions over the nature of these concerns, the ways in which they come to be articulated in public engagement processes, and the substantive contribution this offers for a democratic politics (see Callon et al, 2009; Marres, 2007). There is scope for further reflection in differentiating models of public engagement and the kinds of citizenship offered (building on the typology offered in Table 1).

In attempting to open up the black box of institutional responses to public concerns on the governance of science, our analysis has developed insights into the influences that mediate these processes (as summarised in Table 5). While in-depth in nature, our interviews were conducted broadly across a number of organisations, which limits the insights that we can draw about the relative importance of particular institutional settings, cultures, routines, and practices in opening up and closing down reflection on public values. Detailed longitudinal ethnographic studies within institutions are therefore essential in developing deeper understandings of the underlying processes that mediate and govern the governance of science and technology (see Bijker et al, 2009, for one such ethnographic study). Such work can begin to establish what conditions are necessary to open up institutional reflection about the public value(s) of science, and institutional pre-commitments relating to them, and how this varies across different national and transnational science-policy cultures.

A programme of critical social science for science governance also needs to be constructive and engaged, grounded in collaborative interactions with governance actors and science-policy institutions, in the spirit of collective experimentation (Felt and Wynne, 2007). As noted above, Macnaghten et al. (2005) have outlined such a programme for social science in working interactively to shape the development of emerging technologies in 'real-time'. The findings of this paper,lead us to suggest that the actual mechanisms and innovations in science governance themselves – be they new forms of public dialogue through to emerging frameworks for responsible innovation – should be subject to similar forms of real-time anticipatory reflection and reflexivity: about their underlying purposes, innovation trajectories, social and ethical implications, possible inequalities and so on (see Chilvers, 2012 for an elaboration of this argument). This clarifies further roles for critical social science in working interactively with science-policy to imagine, shape and experiment with

anticipatory, adaptive and inclusive systems of governing in the public interest. We have shown that a key challenge in doing this will be to keep the analyst's eyes open, and open up eyes of others, to the pre-commitments, driving forces and mediating influences that close down institutional reflection on public values and concerns about the governance of science.

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