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Boundary Work in Contemporary Science Policy: A Review

MERLE JACOB

ABSTRACT *This paper looks at the role of boundary work in contemporary science policy. The paper argues that one of the consequences of policy efforts to bridge gaps between science and society is the proliferation of boundary work as new categories have to be constructed and reified in order to make room for particular policy initiatives. In this process of eroding and remaking boundaries, the power to divide, categorise and classify forms a significant starting point for a re-structuring of social, economic and political relations between science and policy.*

Keywords: collaboration; boundary; user; science policy; knowledge.

Introduction

Science and technology studies (STS) takes the study of the relation between science and society as its central theme. For the purposes of academic inquiry, this relation is differentiated into a number of problems or issues, some theoretical and others of a more applied nature. For instance, the study of the role of scientific expertise in policy decisions would be regarded as applied work, while a study of the connection between scientific controversies and revolutionary scientific breakthroughs would be theoretical. This distinction, although more nuanced in practice than these examples imply, has been referred to by Fuller as high (theoretical) and low (applied) church STS.[1] Whether high or low church, STS research (as indicated by the two hypothetical studies described above) studies the boundary between science and society and nowhere is this tendency more apparent than in academic studies of science policy. This paper seeks to answer the question of whether the assumption of a boundary between science and society is still a relevant point of departure for research in science policy, given recent developments in science.

A perusal of the reports of different Organisation for Economic Cooperation and Development (OECD) governments on higher education and research (HER) reveals an overall policy trend towards putting HER to work directly in the service of promoting economic growth and renewal.[2] This trend manifests itself in a

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number of well documented ways,[3] but for the purpose of this paper we shall outline a few key indicators. These are a change in the location of responsibility for HER policy from being the sole preserve of Ministries of Education to HER being a responsibility shared by the Ministry of Education and a number of other Ministries, most significantly the Ministry of Trade and Industry. Sweden and the United Kingdom are among the countries that follow this trend. A second indicator is increased policy efforts to demonstrate the impact of science in terms of utility to industry, or its impact on economic growth.[4] A third indicator is the promotion of the commercialisation of university research and education through a number of indirect and direct measures. One such direct measure is the introduction of technology transfer as a third mission of universities while indirect measures include the promotion of university–industry collaboration and tied research funding (i.e. funding for which academics have to team up with other actors in order to be eligible). These policy trends are strongest in the OECD countries with the European Union (EU) and the OECD being among the two most prominent transnational promoters.[5]

The growing prevalence of the above across national research systems is one of the evidentiary arguments posited to support the claim that at the very least the nature of the boundary between science and society is undergoing change. This hypothesis receives further credence from a number of academic observations, such as the Mode 2 and socially robust knowledge thesis advanced by Nowotny and colleagues,[6] the Triple Helix,[7] and the systems of innovation perspectives,[8] which maintain that knowledge production in the academy is/should be collaborative.[9] The growth of collaboration, and in particular practices such as the inclusion of users/stakeholders/customers in research, has also contributed to the impression that the science–society relation is undergoing radical change. Gibbons and colleagues, for example, have proclaimed the arrival of a second mode of knowledge production in which criteria for evaluation of scientific knowledge include utility and collaboration between scientists and practitioners.[10]

The ontological status of these claims about collapsing boundaries between science and society is ambiguous to say the least, but there are a few signs that these changes in science policy are having an impact on the way science is being organised.[11] According to the OECD, these may be summarised as:

> … a shift from an organisational model based on scientific disciplines to one that places a premium on multidisciplinarity, institutional networking and a blurring between curiosity-driven and problem-oriented research.[12]

More concrete examples include increasing casualisation of academic labour in some countries, the UK being a prime example. Another is a consequence of the orientation of research to ‘relevant problems’. If one examines advertisements for academic jobs in the UK, for instance, it is not uncommon to find that positions are increasingly being defined in terms of specific project requirements rather than research specialisation. This trend is particularly intense at the level of research training (doctoral level) in such countries as the UK and Sweden. Centres and networks are also gradually replacing departments as the sites of research in universities. In recognition of this, one of the growing trends among universities in the EU is to dispense with faculties and introduce schools.

These and other developments at the very least suggest that it may be opportune to re-examine the boundary between science and society in STS studies generally, and particularly in science policy. This paper seeks to answer this question by first reviewing the boundary concept and how it has been employed within STS analyses. The second part of the paper is devoted to answering the main question, i.e. whether the science–society boundary is still a useful analytical and descriptive device in the light of developments in the nature of knowledge production of the Mode 2 and Triple Helix theses. The main argument is that, while on the one hand much is made of science and society growing closer together, on the other contemporary science policy introduces new rhetorical boundaries (e.g. science–knowledge) as well as reifies the science–society boundary. The science–knowledge boundary, for instance, is central to justifying a number of new practices in funding and organising research. The final section of the paper argues that an important outcome of the attempts to conflate or even push back the boundary between science and society has been a reification of this boundary. Together, these two moves have the effect of simulating proximity between science and society while constructing ever more layers or mediators between science and society.

The Boundary Concept in STS

The concept of boundary may be said to be fundamental in STS because it defines the territory under investigation as well as constructing and preserving its rationale. STS research does the first by defining its field of study in terms of dichotomous relations (e.g. science–society, science–policy, science–politics). The second is a consequence of the act of singling out science for special attention. In so doing, STS research inadvertently confirms the special status given to science by providing criteria for demarcating science from other cultural activities in society.

Boundary work is fundamental not only to STS, but to science itself. From its very beginnings as a self-conscious activity, science needed to delineate its activities from other forms of cultural activity. Confirmation of this may be found in Gieryn's study, which showed that scientists attribute special characteristics to science, its practitioners, its methods, and stock of knowledge in order to construct a social boundary between science and non-science, or science and technology.[13] Historically, incidents such as the case of Galileo *versus* the Church of Rome provide warrant for this demarcation. In the history of science policy, J. D. Bernal's *The Social Function of Science* and Vannevar Bush's *Science: the Endless Frontier* provide visions for the way in which the obligations of science to society should be met.[14] The science–technology distinction served to justify and uphold a division of labour between science and industry in which the former created inventions and the latter did commercial innovation.

Likewise within science, boundary work is a necessary strategy employed to differentiate areas of inquiry for institutional or other reasons. For instance, political scientists may wish to define their object of study in a fashion which puts it outside the domain of sociologists and *vice versa*. While much of this boundary work is not intended to imply that the phenomena under study actually fit into these neat categories, the analytical instruments and methods devised will, of necessity, construct the objects of study in a fashion that corresponds to the boundaries drawn up. In fact, the longstanding struggle over achieving inter- and multi-disciplinarity is a sign that boundary work in science has an impact analogous to that described in Benedict Anderson's account of colonial authorities' construction and use of maps and censuses.[15] Anderson showed that the abstract assumptions built into such constructs eventually began to order them materially. One may conclude from this that, although boundaries may be self-conscious or seen as instrumental, the fact that they are constructed to order or create a reality of some kind will eventually have some material impact.

Another example of the importance of boundaries to STS analysis may be found by scrutinising one of the tacit assumptions of STS, which is that science is generally regarded as separate from society. Hence the science–society relation, or the science–policy relation, to name two of the most popular. Many of the first generation of laboratory studies described themselves as putting 'science back into society'. One might quite reasonably contend that this is no more than a rhetorical manoeuvre since science has never been outside of society. Nevertheless, with the aid of this rhetorical device, sociologists of science could highlight their findings about the ways in which science functions as a social enterprise that mimics many of the norms and values of other parts of society.[16] In this regard, one can argue that by showing in what specific ways science is social, sociologists were able to dispute the science–society boundary.

In using boundaries to differentiate among activities or objects, STS usage of the term conforms to the commonsense understanding of boundary. This is not, however, the only way in which STS uses the notion of boundary. One example to which we will devote special attention is the notion of boundary object. This conceptual device merits special attention because it is particularly common in STS research on policy. This concept was introduced by Star and Griesemer to describe terms that are used to build consensus and bridge differences between parties.[17] Boundary objects can build consensus in that they allow sufficient interpretative flexibility for those involved to agree on a particular problem definition without agreeing on its implications or solution.

Since Star and Griesemer's initial study, which focused on ecologists, STS studies have shown that boundary objects are as popular in policy as in science. The concept of sustainable development is one well known boundary object from the area of environmental policy, while the Mode 2 concept may be regarded as having a similar function in science policy. The identification of Mode 2 as a boundary concept may appear to contradict the received view in science policy, which has thus far focused either on highlighting how the advent of Mode 2 has induced convergence in steering mechanisms for science policy, or on showing that the features now associated with Mode 2 have always been present in science.[18] Regardless of which of these views converges most closely to empirical reality, the features associated with Mode 2 are 'embraced by politicians and civil servants struggling to create better mechanisms to link science with innovation'.[19]

A review of different national science policy developments in the OECD countries would show, however, that there are important national differences in the way in which key science policy instruments associated with Mode 2 (such as centres/networks of excellence and collaboration) are designed and realised. Intra-national variations may also occur: for instance, collaboration requirements differ among fields of research. Likewise, some countries require that centres/networks of excellence include non-academic actors (such as firms or public authorities) while others treat centres of excellence as a mechanism for promoting resource agglomeration in a particular field (such as nanotechnology or biosciences). Another possible variation is to focus the centre of excellence on a particular strategic area of application (such as the food and beverage industry).[20] The different uses to which the centre of excellence instrument is currently put has implications not only for how the instrument is designed in each case, but also for the way in which 'excellence' is defined and evaluated. If we take Mode 2 knowledge production to be the cumulative effect of all these different instruments in any given national context, we would find that the concept of Mode 2 fills a similar function in science policy as the term 'sustainable development' does in environmental policy.

Star and Griesmer's concept of boundary object functions both as a descriptive term, as demonstrated above, and as an analytical device. As an analytical device, the notion of boundary object has been used to further the understanding of communication between science and policy, as well as within policy (areas such as climate change, the human genome project and sustainable development).[21] In these studies, the concept of boundary object has been employed to illuminate the way in which science functions in the realm of policy in a manner that earlier devices could not.

In first generation studies of the role of science in policy it was important to maintain a clear boundary between science and policy. A popular tool was the 'science speaks to power' model of Collingridge and Reeves, which assumed a hermetically sealed set of bipolar relations in which scientists produced truth and policymakers made decisions.[22] The increased role of science in policymaking—a phenomenon described by Weingart as the scientification of policy[23]—led to a second generation of studies, which showed that scientists and policymakers communicated and created knowledge for policy in ways that defied the old science speaks to power model. Science policy researchers subsequently posited a number of different devices to describe and illuminate the closing gap between science and policy, including such notions as drift of epistemic criteria, extended peer communities, and postnormal and postacademic science.[24] Although the studies on which these concepts were based provided, and still provide, rich empirical data about the role of science in policy, they were limited by their need to preserve the boundaries that they were trying to explore. The notion of boundary object was, in this sense, more fertile because it gave science policy researchers a means to describe and explain how communication occurs between science and policy without either group necessarily having to adopt the values or goals of the other.

The study of van der Sluijs *et al.* of climate change introduced a second concept which extended Star and Griesemer's notion of boundary objects.[25] According to this study, there are different types of boundary objects. While Star and Griesemer's original boundary object is a flexible device whose very success depends on the ability of actors within a defined community to invest it with different meanings, the van der Sluijs *et al.* notion of anchoring devices is slightly different. Like boundary objects, anchoring devices manage uncertainty by stabilising flux. In other words, they introduce something akin to a Lakatosian hardcore within the discourse which constrains the discourse and prevents it from drifting.[26] Although van der Sluijs *et al.* contend that an anchoring device is a type of boundary object, a more conservative reading of their work would support the argument that an anchoring device could be treated as the fixing point for a boundary object. Without some anchoring device, the discourse about the particular phenomena subsumed under the boundary object would not be productive. Actors could, for instance, deliberately exploit the interpretative flexibility of the term to the point where meaningful communication about the subject at hand would cease. One may reasonably raise the question at this stage as to why actors would engage in this behaviour, given that they have agreed to be bounded by the boundary object. One possible reason for this is that new policy decisions may arise which generate a different coalition of actor interests from those associated with the boundary object. A practical instance of this is the position of the United States on the Kyoto Protocol. Among the arguments given for not supporting the Protocol is that the Protocol does not support sustainable development. This position is then supported by a definition of sustainable development that puts forward the US position on the relation between economic development and environmental protection.

Boundaries in the Face of Changes in Science Policy

Nowhere has the assumption of boundaries been more important than in science policy. Fisher *et al.*'s study of networks of excellence and science policy in Canada argues the point in the following fashion:

> We began our study concerned with boundaries, and the work people do to create, maintain, and break down boundaries between knowledge domains. Boundaries direct attention to power, and to the processes whereby legitimacy and cognitive authority come about. We chose to focus upon the boundaries that are held to separate basic and applied research, science and policy, and public and private conceptions of propriety in knowledge production.[27]

One may be tempted to contend that science policy is nothing more than a series of rituals and practices that make sense only if one assumes that science is a cultural practice with unquestionable utilitarian value. One of the more durable, yet controversial, findings of STS is that there is little warrant for many of the arguments that justify the view that science is a special cultural practice.[28] Developments in science itself, such as the emergence of regulatory sciences, have been read as at least putting into question the validity of a boundary between science and policy. In order to, so to speak, 'save the phenomena', some science policy analysts have resorted to a bit of active boundary work themselves by inventing new categories, such as transscience, mandated science and postnormal science, to accommodate such instances.[29] These new categories of science have, in addition to their explanatory power, a strategic function for STS as a discipline. By positing that some areas of science are externally driven, STS researchers intimate that there is still a core of 'real science' which conforms to the traditional expectations of scientific inquiry (discipline-driven, detached, and so on).

The jury is still out on whether such science–policy interactions warrant the need for a new category/boundary. For example, it could be argued that those who would prefer to introduce a new category to accommodate this type of science are engaging in epistemological gerrymandering for the sake of maintaining the fiction that there is a science that can be described as free from external influences. Still others would argue that the mere assertion that all science is subject to social influence is unproblematic despite the uproar which this claim, in its most naïve form, has caused in some quarters.[30] Further, STS research has set itself the task of determining the ways in which science is social. This includes unpacking the extent to which there is social shaping of science, demonstrating the form(s) of this social shaping, and describing the varieties of strategies adopted in science to accommodate and leverage demands from science and society. Even if one were to concede that all science is socially influenced, one would still need to show how science derives its current epistemic authority over other parts of society. In other words, even 'science as culture' needs to be accountable, and accountability makes sense only if one assumes the relevance of boundaries.

The first generation of scholars of science policy used the notion of social contract to describe the relation between science and society.[31] This contract metaphor was convenient for describing the terms under which public money was allocated to science, and how science would account for this money. In its most idealistic form, the social contract meant that the state assumed that scientific inquiry would produce gains in wealth and welfare for society without active steering. Science's control of its research agenda was seen as an indispensable requirement for guaranteeing the epistemic and political authority of science. This is quite explicit in Vannevar Bush.[32] Although Bush's vision of the science–society contract was never practically realised, science in most OECD countries continues to receive public support, although it has had to cede control of significant parts of its research agenda. The increased political steering of science, some science policy scholars argue, implies that the social contract framework is undergoing radical revision.

It may also be that the increased steering of science is transforming the science–society relation from one that resembles the social contract as outlined by such political philosophers as Locke and Hobbes, to a more legal type of contract. Thus, political steering of science would be no more radical than a buyer specifying the terms of reference to a supplier for the delivery of a specific item.[33] Measures such as tied funding and the promotion of the commercialisation of science, taken together with other types of accountability measures (such as national evaluations of research and education), are indicators of this legalistic turn in the science–society relation. The policy message to science may be that public money will be allocated to science in exchange for concrete outcomes, such as numbers of graduating students, patents, licences and start ups. These new specifications of society's expectations, although quite reasonable on the surface imply a number of boundary transgressions. One of these is the boundary between science and industry. Another is the boundary between public and private. Little is said in the policy discussion about whether universities have the right to profit from research done with public money.

Even as one finds evidence of erosion of the boundaries between public and private, one also observes instances of the creation of new boundaries. An analysis of terminology illustrates and explains this because shift in terminology is often the first marker of policy change. The term 'science policy' is fast becoming old fashioned and is almost always absent from recent reports from governments, the OECD and the European Union which focus on policy for HER. While there is as yet no authoritative replacement for science policy, the terms in use are eloquent. A couple of examples will suffice. The EU has, since at least the 1990s, used the term 'research, technology and development' (RTD) policy. Another is 'research and innovation' policy. RTD and research and innovation policy are distinguished from science policy by their focus on funding knowledge creation rather than scientific research. An examination of these policy documents reveals that the replacement of science with knowledge is a major shift. One way of understanding the meaning of this shift is to reason from Latour's differentiation between science and research.[34] Latour argues that over the past century and a half, we have undergone a transition from a culture of science to a culture of research. The two cultures, he maintains, may be distinguished by the degree of certainty which is ascribed to them, with science representing cold, straight, detached knowledge.

The culture of research, however, is uncertain, risky and tends to create disputes and controversies. The science–knowledge distinction referred to here may be said to be an evolution from Latour's science–research categorisation, with the culture of knowledge being a later, or more modern, stage of the culture of research. In the culture of knowledge, uncertainty and risk are reduced by moving to a pragmatic epistemology in which the actionability of knowledge is included as an additional evaluative criterion. Practices such as including stakeholders' input in defining research programmes and project content are mechanisms for securing actionability. In this sense, knowledge then becomes defined as the capacity to act, and science as a means for producing information that may or may not lead to actionable knowledge.

Knowledge, unlike science, is instrumental in its intent; it aims not just to understand nature or society, but to manipulate them to produce welfare and wealth. In order to achieve this, knowledge production often requires the transformation of that which was previously presumed to be common property (e.g. publicly-funded science) to proprietary information.

Knowledge and science may be further differentiated by looking more closely at the evaluative criteria employed. In science, the emphasis is on such factors as publications, citations, and Nobel Prizes, while knowledge is evaluated though quite different factors—patents, licences, stock value of spin offs, network heterogeneity and size. While science is a self-regulating enterprise, knowledge seems to require governance and networks to ensure its creation and diffusion.

A cornerstone of RTD or research and innovation policy and a critical marker of the shift from science to knowledge, has been the promotion of collaborative research programmes. Collaborative research is a multifaceted category, but reduced to its essence it usually requires that researchers identify a group of users or stakeholders for their research and actively seek input from such groups. In most cases, this is a precondition for the programme to be eligible for funding. The nature of the involvement of these groups depends on the ambitions of the major funder, but it can range from involvement in all stages of the research process to a consultative role. The rationale for collaborative research is that it guarantees that the results produced will be of utility to the intended target group by bringing the research and practitioner community closer.

This rationale may be extended beyond the research programme or project in that some funders would also like to promote the formation of networks of users/stakeholders and researchers that will outlive the particular programme or project. At first sight, it seems that even if only some of the ambitions embedded in collaborative research are realised, the traditional boundary between science and society will be eroded. Ironically, however, collaboration appears to stimulate active boundary work. This boundary work is necessary both to justify collaboration, construct eligibility criteria for collaboration, and even evaluative criteria for outcomes. Shove and Rip elaborate on this analysis of the interpretative flexibility of the category 'user'.[35] They argue that both researchers and research funders are forced, as a result of collaboration requirements, to define and construct users to fill the purposes and notions of use embedded in collaborative research. Despite, or perhaps because of, all the talk of giving users the opportunity to voice their needs, both researchers and their funders have a range of expectations and needs that the user must fulfil in order to qualify as a user. From the perspective of the funder, users are necessary in order to attest to the relevance of research to society both in a general sense, as well as in the specific sense of having put the research to use.[36] Researchers want users who are influential and in a position to implement the results of the research. Such criteria imply that researchers need to select users who are fairly well known or whose function and significance is easily identifiable. Although Shove and Rip's analysis is based on the UK's Economic and Social Science Research Council, an analysis of Swedish research councils who support collaborative research shows similar results.[37] Interestingly enough, similar transformations and boundary work may be observed in the context of other public sector initiatives in Sweden. For instance, the arrival of new public sector management in Sweden has, like elsewhere, required that citizens become customers.[38]

These analyses indicate that changes in the way knowledge production is organised have introduced the need for the creation of new categories or proxies for society. The justification for collaboration is that it produces accountability by ensuring relevance. While this may appear plausible, it is dependent on a number of predefined conditions. One of these is that we can find users who are sufficiently non-academic to justify the user–researcher boundary which the narrative presumes. Then the actual business of collaboration has to be enacted according to a script that researchers and their funders have written long before any of them confronts any of these users. It follows from this that one cannot just find users on the street; users have to be constructed, even prepared and briefed. As if in recognition of this, one Swedish research council has taken a further step and introduced training programmes for users.[39] The first of these courses was initiated in 2004 and, according to the council's own reports, it has been an overwhelming success. The course is open to researchers and users and seems to indicate that the author of the script to which users and researchers must conform is the research council. It may be that this balance of power shifts depending on the nature of the project, but research councils control the scripts either overtly (as in the case above) or implicitly. Implicit control is via structuring of the initial call, choice of users, and the level of involvement users are allowed in the programme.[40]

It seems that a major new boundary has been created: user–society. While this boundary is key to collaborative research, a range of similar boundaries is also evident in the collaborative enterprise, such as researcher–practitioner and researcher–stakeholder. Having established the boundaries needed to justify its practices, collaborative research then proceeds to introduce practices that are specifically aimed at building bridges across these boundaries. This, in part, explains the emergence of a number of hybrid categories, such as practitioner–researcher (practitioners who are engaged in research within the project in which they have been enrolled).

In collaboration, researchers and funders alike have to engage in boundary work to ensure that the requirements of the script are met. This elaborate dance of definition and construction is, in one sense, transgressing the boundary between science and society in so far as it successfully manages to construct boundaries and find actors to play the required roles. In another sense, it brings society into science by persuading society's actors to play the part researchers and/or their funders have decided they should play.

One of the effects of the above that is seldom mentioned is that the categories 'science' and 'society' are increasingly being recognised (certainly in the practices of researchers and funders) as fragmented rather than homogeneous entities. We now have a society which, for the purposes of collaboration and different rituals of accountability, is divided into various groups of stakeholders, users, clients and customers who, in turn, are hierarchically arranged, depending on the part they are scripted to play in these rituals. Thus, the same actor may 'stand in' for society in several different roles. Science itself undergoes a similar process of fragmentation with an implicit distinction being made at the level of policy between science and knowledge. This distinction, in turn, produces a number of new social relations within the HER sector. For example, those organisations that produce knowledge are now seen as entrepreneurial, while those that produce science may be described as traditional. Scientists themselves may also be divided into those who are academic entrepreneurs and those who are mere researchers.

Conclusions

In summary, science policy in OECD countries has changed significantly in the last two decades. The emergence of steering devices in science policy, explicitly devised to eradicate boundaries between science and society, has given rise to the expectation that STS analytical constructs, such as boundaries and boundary objects, are no longer relevant. Practices such as collaboration, integration of users in evaluation panels, and the introduction of new relevance and utility criteria for evaluating knowledge, have paradoxically led to the creation of new boundaries within science policy. These practices appear to facilitate closer interaction between science and society, but closer examination reveals that society is being represented by a select group of actors who have to be coached to play the part ascribed to them by research councils.

These policy trends have not been without impact on the way research is organised. The most significant changes include reorganisation of universities into schools rather than faculties, and the movement away from the discipline-based department to the centre or network as the preferred location of research. Not surprisingly, changes in the organisation of research and policies for governing research will have some impact on the analytical categories employed in research into these phenomena. STS research on science policy has traditionally focussed on the boundaries between science and society. Analytical constructs, such as boundary objects, boundary work and anchoring devices, are examples of this deployment of the concept of boundary as an analytical category. This has been particularly useful in science policy research and in research which seeks to map and explain the complexity of science–policy interaction. The changes in science policy and their consequences for the organisation of research have eroded some boundaries through the inclusion of new actors who stand in for society while creating new boundaries within science itself.

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22. David Collingridge and Colin Reeve, *Science Speaks to Power: The Role of Experts in Policy-making*, Frances Pinter, London, 1986.
23. P. Weingart, 'Scientific expertise and political accountability: paradoxes of science in politics', *Science and Public Policy*, 26, 3, 1999, pp. 151–61.
24. A. Elzinga, 'Research bureaucracy and the drift of epistemic criteria', in B. Wittrock and A. Elzinga (eds), *The University Research System: The Public Policies of the Home of Scientists*, Almqvist and Wiksell, Stockholm, 1985, pp. 191–220; S. Funtowicz and J. Ravetz, 'Three types of risk assessment and the emergence of post-normal science', in S. Krimsky and D. Golding (eds), *Social Theories of Risk*, Praeger, London, 1992, pp. 251–74.
25. J. van der Sluijs, J. van Eijndhoven, S. Shackley and B. Wynne, 'Anchoring devices in science for policy: the case of consensus around climate sensitivity', *Social Studies of Science*, 28, 2, 1998, pp. 291–323.
26. Lakatos argues that scientific theories contain a hardcore of hypotheses which, unlike the rest of the theory, are not subject to refutation. I. Lakatos, 'Falsification and the methodology of scientific research programmes', in I. Lakatos and A. Musgrave (eds), *Criticism and the Growth of Knowledge: Proceedings of the International Colloquium in the Philosophy of Science, Volume 4,* Cambridge University Press, Cambridge, 1965, pp. 91–196.
27. Fisher *et al.*, *op. cit.*, p. 301.
28. These findings are durable in so far as they have been replicated by several STS studies, but they remain controversial among disciplinary communities outside of STS. See P. R. Gross and N. Levitt, *Higher Superstition: The Academic Left and its Quarrels with Science*, Johns Hopkins University Press, Baltimore, 1997; and A. Sokal, *Fashionable Nonsense: Postmodern Intellectuals' Abuse of Science,* Saint Martin's Press, New York, 1999.
29. A. Weinberg, 'Science and trans-science', *Minerva*, 10, 1972, pp. 209–22; L. Salter, E. Levy and W. Leiss, *Mandated Science: Science and Scientists in the Making of Standards*, Kluwer Academic Publishers, Dordtrecht, 1988; Funtowicz and Ravetz, *op. cit.*, pp. 251–74.
30. D. Demeritt, 'The construction of global warming and the politics of science', *Annals of the Association of American Geographers*, 9, 2, 2001, pp. 307–37.
31. David Guston and K. Keniston, *The Fragile Contract: University Science and the Government*, MIT Press, Cambridge, MA, 1994; D. Demeritt, 'The new social contract for science: accountability, relevance, and value in US and UK science and research policy', *Antipode*, 32, 2000, pp. 308–29.
32. Bush, *op. cit.*
33. This view suffers from a similar degree of idealism as the earlier social contract arguments. Two of the most obvious limitations are that science cannot specify its outcomes in advance in the same way that a baker can guarantee the production of a loaf of bread. The second is that both the buyer and the seller in science often suffer from imperfect knowledge of what is practically possible.
34. B. Latour, 'From the world of science to the world of research', *Science,* 280, 5361, 1998, pp. 208–10.
35. E. Shove and A. Rip, 'Users and unicorns: a discussion of mythical beasts in interactive science', *Science and Public Policy*, 27, 3, 2000, pp. 175–82.
36. N. Morris, 'Science policy in action: policy and the researcher', *Minerva*, 38, 2000, pp. 425–51.
37. T. Hellström and M. Jacob, 'Taming unruly science and saving national competitiveness: discourses on science by Sweden's strategic research bodies', *Science, Technology and Human Values*, forthcoming.

38. N. Pollock, 'The "self-service" student: building enterprise-wide systems into universities', *Prometheus*, 21, 1, 2003, pp. 101–20.
39. MISTRA internal newsletter, January 2005 (available in Swedish only). INNOVA, the Swedish Agency for Innovation Systems, also holds courses for public sector managers in something the agency calls 'Triple Helix management'.
40. Thanks to an anonymous reviewer for pointing out this aspect of the dynamic of the relation between users, councils and researchers.