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Continuity in Discontinuity: Changing Discourses of Science in a Market Economy

Laurie Cohen
Loughborough University

John McAuley
Sheffield Hallam University

Joanne Duberley
University of Sheffield

There is an emerging consensus that we are experiencing radical change in the way that science is organized and performed. Frequently described as a shift from Mode 1 to Mode 2, this view emphasizes application, transdisciplinarity, collaboration, and accountability. This article examines the ways in which U.K. public sector scientists make sense of scientific endeavor. The data reveal that the extent to which science is being constructed varied both across and between institutions. Data highlight how individual scientists weave their own paths through the changing discourses of science, constructing new understandings that do not fit neatly into any binary framework for understanding.

Science, it seems, is changing. There is an emerging consensus that we are experiencing a “radical, irreversible, worldwide transformation in the way that science is organized and performed” (Ziman 1994, 7). Central to this emerging approach is an emphasis on contexts of application, transdisciplinarity, networking and collaboration, and social accountability (Gibbons et al., 1994; Ziman 1994, 1996, 2000; Hicks and Katz 1996; Turpin, Garrett-Jones and Rankin 1996; Jansen 1995). And with these apparent changes in the practice of scientific research are new ways of talking about science (Oswick and Grant 1996; Tietze 1998). Metaphors of “discovery,” “forging frontiers,” and “working at the cutting edge” are giving way to an idea of science as “wealth creating,” and “life enhancing,” “competitive,” “market oriented,” and “entrepreneurial.”
There is also a political and economic agenda. There is, in the United Kingdom, a political view that science is the “bedrock of the country’s future economic performance” (Major 1998, xxiii). This view sees the purpose of scientific endeavor as the “generation of national prosperity and the improvement of quality of life” (Cm2250 1993, 2). According to this prescription, publicly funded research should take its lead from industry and other user communities to ensure that its work addresses real problems, thus benefiting industry and (by extension) the country as a whole.

These intellectual and political preoccupations may be found in science policies in countries as diverse as the United States (Jordan 1999), Germany (Bührer 1999), and Spain (Alonso, Fernandez, and Sanz-Menendez 1999). However, if the process of knowledge production is indeed changing, research is needed into just how this change is perceived and experienced by a whole range of stakeholders within scientific networks and into the relationship between processes of knowledge production and current understandings of the political agenda. Government strategy for science operates at a macro level to be made sense of and implemented, within boundaries, by the research councils and institutes according to their own circumstances and contexts. Thus, it was the case that the eight establishments in our study had incorporated these strategies into their own scientific agendas in different ways. Some found themselves in a strong market position and did a great deal of commissioned research. Others had developed a “mixed economy model” (Cook 1996, 11), and two establishments saw themselves as having very limited commercial potential and thus did little contract or commissioned work. This article seeks to examine the ways in which scientists, subject to the same policy and with awareness of different modes of scientific work, make sense of approaches to scientific endeavor and science policy.

In the first section, we introduce the study on which this article is based and outline our methodological approach. The literature review discusses the relationship between discovery and application, considering traditional, linear approaches to this relationship as well as more holistic perspectives based on convergence and synthesis. With this debate as background, we then consider the argument that new approaches to scientific research and the production of scientific knowledge are emerging, focusing in particular on the Mode 1/Mode 2 framework put forward by Gibbons et al. (1994). We locate this discussion within the changing context of public sector science using the United Kingdom as an example. In the fourth section, we present our findings using four categories: context, discipline base, social organization, and accountability/quality control, derived from the work of Gibbons and his colleagues, as the basis of our analysis. Finally, we discuss the implications of these findings.
Methodological Approach: Examining Scientists’ Perceptions and Experiences of Their Changing Work Contexts

This qualitative study is based on work undertaken in eight public sector research science institutes and surveys, all of which operate under the auspices of a single research council. These organizations were chosen because they have a number of key similarities and differences. They are situated in the same structural position vis-à-vis their research council and the Department of Trade and Industry, the government department responsible for science and technology policy. These institutes operate in a semiautonomous mode in that the research council is responsible for the overall strategic direction of the institutes and is also responsible for aspects of monitoring and evaluation of their work. All the participating organizations characterize themselves as world class in their particular scientific endeavor.

However, the nature of their work (including disciplines as diverse as ecology, polar science, marine biology, and geology) and the contexts in which they operate are somewhat different. The issue of funding and the position of each of these organizations in the marketplace are of particular significance. While some participating organizations received as much as 70 percent of their funding directly from the research council, for others this core budget amounted to as little as 20 percent. Such organizations generated up to 80 percent of their funding through commercial activities.

Between 1996 and 1998, fifty-five semi-structured interviews were conducted with individual research scientists from Higher Scientific Officer to Director level. Interviews focused on such issues as changing working contexts; the research process, that is, the relationship between science budget and commercial research; perceptions of external bodies, such as research councils and government departments; and scientists’ personal career "stories," including their expectations, fascinations, opportunities, and career aims. Following these interviews, reports summarizing the main findings were prepared and disseminated to interviewees and institute senior management, and in some cases, feedback seminars were held during which our preliminary findings were shared with respondents to check our interpretations and facilitate further debate among participants.

Our research has been within the subjectivist, interpretative tradition of social science. Central to this perspective is an emphasis on the process by which actors construct their reality (or realities) (Harrison 1994; Meyer and Rowan 1977; Tolbert and Barley 1991; Law 1994). The production of scientific knowledge, according to this interpretivist perspective, is understood to be socially constructed (Latour and Woolgar 1979; Latour 1987; Callon, Law, and Rip 1986; Jasanoff et al. 1995; Kleinman 1998). In this spirit, the
data we present are not to be taken as the truth of the matter. As analytical observers, we were aware (for we had heard other accounts) of misrepresentations of a glowing mythic past, of projections and interjections and other manifestations of defensive behavior in which members engage to make sense of the circumstances in which they find themselves.

Making Sense of Theoretical Dichotomies: The Relationship between Discovery and Application

An underpinning feature of Western thought is the tension between, on one hand, dualistic modes of thought and, on the other hand, those modes of thought and feeling that express our relationship to nature in holistic terms. Both in the literature and among our interviewees, this is a contested area with moments of conflict and moments of conciliation. Permeating the literature on the nature of science is the relationship between science and practical action (Parsons 1951), basic and applied research, science and innovation, and discovery and innovation (Ziman 1996; Miller 1986; Kealey 1996). This distinction between basic and applied research has traditionally been used as a basis for the organization of research science. Indeed, in our study, scientists frequently associated discovery science with the “ivory towers” of old universities and applied science with industrial contexts. Their own institutes, many suggested, occupied a somewhat ambiguous middle ground.

Central to these dichotomies are contrasting notions of abstraction and application. Implicit in conventional definitions generally is a linear relationship between science and technology (Lovelace 1986), with scientific breakthroughs leading to technological innovations. Such conceptualizations are based on a two-stage process, whereby discovery, that is, the process of “getting ideas,” is followed by a second, innovative stage during which these ideas are put into action (Freeman 1982).

This linear model has been called into question (Kealey 1996; Rickards 1991; Koestler 1970; Turpin and Deville 1995; Cook 1996; Rubin 1992). Kealey (1996) maintains that such a framework is overly reductionist. Explaining the difference between science and technology, he suggests that while “technology is the activity of manipulating nature, science is the activity of learning about nature” (p. 24). He argues that the relationship between the concepts is often far more complex, sometimes characterized by interdependence and reciprocity and sometimes by separation. Similarly, Rickards (1991) questions the tendency, both in academic and more popular contexts, to conflate the concepts of creativity and innovation, resulting in understandings that are bland and uncritical and that offer little explanatory value.
Jansen (1995) takes as her starting point the idea that there is an increasing convergence between basic and applied science in the organization of scientific research. In particular, she emphasizes the extent to which both dimensions now occur within the same organizations. In this light, she set out to examine whether the aims and motives of scientists have also merged. She found that they have not. Her study of German high-temperature superconductor research revealed that those scientists who saw themselves as applied researchers were interested in long-term relevance and followed a variety of paths in pursuit of their goals. On the other hand, those who saw themselves as basic researchers sought highly specialized, intellectually challenging projects and aimed to produce “generic” knowledge, not linked to a particular industrial context. Her data thus suggest fundamental differences in scientists’ perceptions. This is not to imply that the aims of basic and applied research are necessarily incompatible. Rather, the key point is that the scientists in her study constructed them as such.

Are Discourses of Science and the Production of Scientific Knowledge Changing?

At the heart of this debate is an emergent discourse about the nature and process of knowledge production (Gibbons et al. 1994; Hicks and Katz 1996; Ziman 1994, 1996, 2000; Turpin, Garret-Jones, and Rankin 1996). Central to this debate is the view that “academic science is undergoing a cultural revolution. It is giving way to ‘post-academic’ science, which may be so different sociologically and philosophically that it will produce a different type of knowledge” (Ziman 1996, 752).

As Gibbons et al. (1994) argue, not only will this have an impact on the nature of the knowledge produced “but also how it is produced; the context in which it is pursued, the way it is organized, the reward systems it utilizes and the mechanisms that control the quality of that which is produced” (p. vii). They describe this change as a shift from “Mode 1” to “Mode 2” knowledge production. Mode 1 refers to the more traditional practice of science, “created within a disciplinary, primarily cognitive context” (p. 1), situated within universities, and characterized by a polarization of discovery and application. In contrast, Mode 2, also referred to as “post-academic” and “steady state” (Ziman 1994, 1996) “is created in broader transdisciplinary social and economic contexts” (p. 1), and is based on the principles of convergence and synthesis. Gibbons et al. (1994) examine the change in terms of five key dimensions: context, discipline base, social organization, accountability, and quality control (see Table 1). They maintain that Mode 2 has not replaced Mode 1 but is emerging alongside it.
<table>
<thead>
<tr>
<th>Mode 1</th>
<th>Mode 2</th>
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<tr>
<td><strong>Context</strong></td>
<td><strong>Mode 2</strong></td>
</tr>
<tr>
<td>Problems are situated and examined in an academic context in relation to the cognitive and social norms of basic research. Research is driven by the interests of a specific academic community, with no specified, practical outcome.</td>
<td>Research is intended to be useful to industry, government, or society at large and is organized around a specific issue or problem. Knowledge is produced in negotiation with diverse stakeholders and reflects their interests.</td>
</tr>
<tr>
<td><strong>Discipline base</strong></td>
<td><strong>Knowledge is transdisciplinary, integrating different skills, cognitions, and social norms of various stakeholders and establishing consensus. Dynamic flow between theory and application.</strong></td>
</tr>
<tr>
<td>Knowledge is developed consistent with the frames of reference, cognitions, and social norms of specific academic disciplines. Distinction between theory and application.</td>
<td>Knowledge production is deeply institutionalized and typically based in universities and colleges with limited multiagency collaboration. Research teams are discipline based and long term in their orientation.</td>
</tr>
<tr>
<td><strong>Social organization</strong></td>
<td><strong>Knowledge is produced in diverse organizational contexts, including universities, nonuniversity research institutes, government agencies, not-for-profit organizations, industry, and consultancies. Research teams are transitory and diverse, incorporating people with a range of skills and experience as necessary. The composition of teams changes as problems evolve and new issues emerge.</strong></td>
</tr>
<tr>
<td>Accountability and quality control</td>
<td>Researchers are accountable to and judged by their peers through peer review. The scientist is seen as expert, disseminating knowledge to a largely uninformed and undifferentiated public. Quality is based on notion of scientific excellence, measured against existing disciplinary cognitions and norms. A key consideration is whether the research is seen to contribute to the discipline.</td>
</tr>
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SOURCE: Adapted from Gibbons et al. (1994).
Gibbons et al. (1994) insist that their framework is value free—that Mode 2 is not inherently better than Mode 1, or vice versa; rather, they must be seen as fundamentally different, with their own particular sets of cognitions, social norms, and values. However, they do modify this strict polarization somewhat, suggesting that “the way in which Mode 2 becomes established in a particular context will be determined by the degree to which Mode 1 institutions wish to adapt themselves to the new situation” (p. 14). Gibbons and his colleagues do not elaborate on this point. Instead, their book is centrally concerned with how knowledge production in Mode 2 is conceptualized in different institutional contexts. In spite of the reference to the issue of process, it seems to us that implicit in their framework is an apparently seamless transition from one mode to the other.

Science in the Marketplace

It could be argued, however, that the emergence of the Mode 2 approach as the preferred model, the “imperializing discourse” (Prichard and Willmott 1997), is inextricably intertwined with political and economic exigencies. A Marxist gaze puts a very different gloss on the matter. In this perspective, the sort of science that is predominant at any one time “is determined by the influence that economic factors exercise in the development of science” (Müller 1979, 90). Müller goes on to suggest that in capitalist countries, the relative decline of interest in basic science is a manifestation of the economic cycle such that science policy is “governed by short-term tactical or anti-inflationary objectives.” There was some support for this view among our interviewees, although their political orientation would not be described as Marxist.

During the late 1980s and 1990s, there was a change within the U.K. government in the understanding of the nature of the public service organization and its relation to society. Although the approach known as New Public Management (Hood 1991) has been theorized in a variety of ways, there is a number of core characteristics that recurs across the spectrum of definitions. Publicly funded science is understood to be a bedrock activity in the modern society, with an emphasis on the notion of use and application (e.g., Cm2250 1993; Cook 1996). There is an expectation that there will be intense collaboration with industry and other users such that Boden et al. (1998) found that “the introduction of customer-contractor relationships have almost ubiquitously been described to us as the reform which has had the biggest single change on work and organization” (p. 17). Processes of legalistic contracting
and rigorous structures of accountability (Pollitt 1993; McKevitt and Lawton 1994) replace a collegial environment of trust based on psychological contracts (Boden et al. 1998). Thus, we suggest that there is a fit between the parameters of context, discipline base, social organization, and accountability between government strategies for science and the emergence of a preference for Mode 2 approaches to science. The development of research capability and the ways in which the “system is responding to reduced growth in the money allocated to it” (Hicks and Katz 1996, 403) is a background (but crucial) issue that preoccupied many of our interviewees.

Scientists’ Understandings of Their Intellectual and Political Environments

The sections that follow consider respondents’ stories in terms of the categories identified by Gibbons et al. (1994): context, discipline base, social organization, and accountability/quality control. We have chosen to focus on their Mode 1/Mode 2 analysis because it clearly outlines the key dimensions of this debate (see Ziman 1994, 1996, 2000; Hicks and Katz 1996) and provides a useful framework, which we have used non-normatively, within which to situate our findings. In using these categories, we are not suggesting that they are discrete or mutually exclusive; on the contrary, as will be shown, there is considerable overlap between them in the practical undertaking of science or knowledge production.

Context: Academic Communities or Contexts of Application?

Gibbons et al. (1994) suggest that whereas in Mode 1, knowledge production proceeded “in the absence of some practical goal” (p. 4), within Mode 2 “knowledge is intended to be useful to someone, whether in industry or government, or society more generally, and this imperative is present from the beginning” (p. 4). This increasing emphasis on usefulness and contextual relevance emerged as a central theme in respondents’ accounts.

It became apparent that scientists working in institutions that were heavily reliant on commercial funding tended to espouse Mode 2 discourses. These respondents described themselves as working closely with their users, sharing a common perspective, and identifying with their needs:

“We’re really just one step removed from the farmers. It’s all about working together, about technology transfer.”
These respondents hoped that through their commissioned projects, they would be able to fulfill their scientific goals. In contrast to the scientists in Jansen’s (1995) study, who clearly demarcated basic from applied goals, there is a sense that old dichotomies are indeed giving way to understandings based more on convergence and synthesis (Ziman 1996, 2000).

The distinction between science budget work and commissioned work is a red herring. Scientific discovery can happen anywhere. So in a sense, just start anywhere.

In particular, they suggested that commissioning organizations tend to focus on science that can be applied to specific problems rather than more speculative research.

The interests and requirements of our [commissioning organizations] have changed. Over the last couple of years, it’s become clear that proposing a piece of research which might help to explain, say, the functioning of a vegetation system in a developing country and the link between that and the population problem—understanding that problem is not enough. Now [our client] requires that you draw a pathway from your research right through to the person who will benefit from that research.

As commercial work has become more important, the research council and senior managers within the labs have begun to acknowledge the contribution of more applied outputs. To a number of scientists in our study, this shift in focus made sense. In light of changes in funding patterns and the increasing emphasis on delivering explicit outputs, several said that they were beginning to reevaluate their own ideas about scientific purpose:

We need to educate ourselves in the more applied aspects of problems overseas, and we are learning. It really is an educative experience, being on the ground, asking more questions . . . I am seeing the light.

Furthermore, scientists explained how their ideas about scientific purpose and about the most appropriate context for scientific research had changed over time, not only in response to changing political, economic, social/cultural and organizational circumstances but also at different points in their careers.

However, all the scientists in our study did not share this rhetoric. Rather, we noted that the increasing emphasis on application seemed to be most problematic for those scientists who were least involved in commercial research. As the acting director of a largely core-funded establishment noted,
So we come under pressure from [the research council] to find ways of getting up our count of commercial or commissioned research so that the figures look better for the Office of Science and Technology and the Department of Trade and Industry so that the chief executive can get his bloody bonus. . . . But I see that work as an interference. We could end up doing a piece of work for the insurance companies to do with the impact of space weather on spacecraft and therefore on insurance premiums for damage to spacecraft on orbit. Now that will do nothing for the field of geospace research. OK, it will do something for the insurance companies . . . but it will do absolutely nothing for the main mission of my department.

Embedded in this account is a discourse about “good” science—a discourse grounded in the traditional distinction between discovery and application. Whereas discovery questions were seen as expansive and emergent, applied interests were described as more restricted and narrower in scope. And these perspectives were not value neutral. Whereas applied science was seen as important and necessary, although often mundane, discovery science was high status, exciting, and fun.

Many of our respondents suggest that there is a paradox at the heart of the implementation of science policy. Whereas current policy aims at holism and integration, the actual funding mechanisms make a split between what is valued in terms of Mode 1 and Mode 2 outputs. While scientists in some labs felt the two sets of expectations were incompatible, others explained that a successful synthesis was possible and, in some cases, had been achieved. Specifically, those scientists who were most heavily involved in commercial research explained how their ideas about what science was for were indeed changing to encompass a more reciprocal relationship between academic, discovery science and application.

One of the challenges is to actually get as much science out of the project as you can, and this is why I say we are in a lucky position to some extent that we can choose contracts which are attractive to us in the science field. We can see potential science, and we have very good relations with our large customers . . . and we can alert them to issues which we think they should be looking at, and hopefully, they may well fund the research.

Thus, we have a view of scientific purpose as multifaceted and dynamic. As Kealey (1996) argues, it can be understood in terms of intellectual, economic, and political value and on many different levels. The purpose defined by policy makers might well be very different from that defined by commercial customers, the scientists themselves, or by the general public. As the deputy director of one research establishment (which, it should be noted,
operated in a politically sensitive area but did very little commercial work) explained,

I think that the government’s reason for funding us is undoubtedly to do with foreign policy and strategy and has very little to do with research and education. On the other hand, the research council and our director’s reasoning is to do with research. But you do get the feeling that somehow that gets boiled down to just doing things with good publicity value or producing lots of papers. Whereas down at the individual level, you just feel you want to do good research, and this is what our mission should be.

What we see here is an awareness among the scientists of the contextual issues that surround them and of the development of discourses that legitimate the stance they take in relation to the political contingencies that confront them. Thus, support for and resistance to these factors are grounded in their understanding of what it is to be a scientist.

**Discipline Base**

In addition to being embedded within and inseparable from its context, commentators have suggested that knowledge production is now transdisciplinary (Turpin, Garret-Jones, and Rankin 1996; Ziman 1994, 2000). Indeed, Ziman (1996) argues that “the most radical feature of post-academic science could be its unselfconcious pluralism” (p. 753). In contrast to Mode 1 approaches, which emphasize the production of knowledge within well-defined, discipline-based orthodoxies, central to knowledge production in Mode 2 is an integration of different theoretical perspectives in response to and guided by the particular problem being addressed. Knowledge in this sense is fundamentally creative and dynamic, constructing “its own distinct theoretical structures, research methods and modes of practice” (Ziman 1996, 5).

As regards this study, the issue of transdisciplinarity relates to the ways in which science is organized within the participating labs. In particular, scientists explained that the development of matrix structures and cross-disciplinary teams reflects the extent to which the work of their organizations transcends traditional academic boundaries and is oriented to “real world” questions.

Among our respondents was a consensus that traditional discipline-based approaches were inadequate for grappling with the complex environmental issues that were of central concern to their organizations. However, having completed their training within academic departments, many expressed ambivalence about working across disciplines (Ziman 1987). In particular, they missed the opportunity to focus on a particular problem over a sustained
period and felt that, at times, their research was superficial, “scratching the surface” of the problem but failing to develop deep, complex understandings.

Because of the nature of the work nothing is long-term. You do three or four years in small mammals, and then it might be ecotox. It might be all birds but from different aspects. I mean, I’ve worked on urban birds, wading birds, ducks, desert birds, woodland birds, you know, all sorts. So you become a jack-of-all-trades. But the sort of long-term, fairly specialized expert, really in-depth study stuff—that’s gone. . . . It’s got plusses and minuses. Losing people with great in-depth knowledge, you know, of one or two subjects, is sad, because they come up with insights that dabblers will never have. We do need more people like that, but it is quite interesting to do a number of things, make connections, get your fingers in lots of pies, lots of ideas. It’s swings and roundabouts. You need both, but the shame is when people are forced into dabbling when they really would like to get stuck into something for ten years. But these days, everything has to have outputs.

In spite of such misgivings, however, there was a consensus among our respondents that research into the natural environment necessarily spanned discipline boundaries and that working in this way was part and parcel of the institute context. In contrast to university departments, which they said were typically driven by disciplinary interests, these public sector labs are oriented around certain scientific issues and problems that are necessarily informed by knowledge and expertise from a range of academic perspectives and disciplines.1

Thus, contrary to Gibbons et al. (1994), who suggest that the current emphasis on transdisciplinarity represents a shift in approaches to knowledge production, our respondents did not describe this way of working as anything new, even when they were working in Mode 1 arenas.

Social Organization

Linked with transdisciplinarity is the issue of multiagency collaboration. Not only does Mode 2 knowledge production involve a range of disciplines, but it also includes individuals with diverse skills and experiences, working in a variety of institutional and organizational contexts (Rubin 1992; Turpin, Garrett-Jones, and Rankin 1996). In the case of scientific knowledge, this has meant an emphasis on interaction (often on an international basis) between public sector research establishments, government departments, industry, and universities. All of the scientists we interviewed participated in multiagency teams, explaining that such collaboration was inevitable both in terms of current funding structures and the scope and complexity of public sector scientific research. However, like the scientists in Turpin and Deville’s (1995)
research, their experiences of such arrangements are mixed, with some individuals describing their disillusionment and frustration with what they see as unwieldy processes.

The key challenge, which fills me with considerable anxiety, is that I am consortium leader for a piece of work on climate change [funded by the research council] with involvement from research institutes, universities, government departments. The elements in the consortium still don’t hold together very well in my view. I find particularly we have a [university] modeling group who always seem to want to plow a furrow that doesn’t fit. I have no direct control because they are funded separately and so I have to jolly them along as best I can. This is a major challenge. . . . It’s something I rather dread.

However, many of our respondents suggested that notwithstanding the pain caused by the scale of such arrangements, these relationships could yield exciting developments. This is a view shared with a number of writers (Ziman 1994; Turpin, Garrett-Jones, and Rankin 1996; Tunisini and Zanfei 1998).

When asked specifically about relationships with their customers and collaborators, there was often some ambiguity. For example, in a South African project, while the funding came from the European Union, it was administered through a number of South African government departments. These departments all had representatives working alongside institute scientists on the project team—so they were at once collaborators and clients. In these diverse teams, roles, aims, and expectations were not static and could not be taken for granted; rather, they were transitory, vague, and frequently misunderstood.

These data echo current debates about changing relationships between knowledge producers and knowledge users—debates central to the Mode 1/Mode 2 dichotomy. Such changes have been explored by academic working areas, including public sector management (Potter 1994), critical accountancy (Boden et al. 1998), enterprise and entrepreneurship (Du Gay and Salaman 1992), the culture of consumption (Baudrillard 1998), and public understandings of science (Irwin and Wynne 1996). Although diverse, these approaches all pose a challenge to simplistic, polarized dualities, such as consumption and production, service providers and service users, and scientists and the public. They take issue with traditional “deficit” models of understanding, in which the “provider” (scientist, professional, etc.) is seen as the expert, imparting knowledge to a largely uninformed (and undifferentiated) public. In place of deficit perspectives, theorists are pointing to “relational” models of interaction (MacNeil 1985; Duberley and Johnson 1999). However, managing relationships in these dynamic contexts, where traditional boundaries between
the contractor and the customer are subject to continual negotiation and redefinition and where professional, scientific, organizational, institutional, and national borders are transcended, was seen by respondents as a considerable challenge.

All of the scientists in our study agreed that teamwork and multiagency collaboration were central to scientific research. The increase in European-funded research and the emphasis on private-public sector cooperation has led to complex large networks. In those institutes in which commissioned work was significant, it was also the case that many individuals were now involved in more projects and participated in a greater number of teams than had previously been the case.

This is not to suggest that multiagency collaboration did not happen before or that the social organization of public sector science had been radically transformed (as in a shift from Mode 1 to Mode 2). In our view, the extent to which negotiation between diverse actors as central to the scientific process can really be considered a new idea is questionable. Long before the current debates around Modes 1 and 2, writers (e.g., Sayles and Chandler 1971; Latour and Woolgar 1979) found that the production of scientific knowledge was fundamentally achieved through negotiation between a whole web of stakeholders. While we recognize that the scope and complexity of these collaborations have changed, the notion of scientific research as an interactive activity has not. We must be mindful, then, to examine both continuity and discontinuity and not ignore those things that have stayed the same or that change incrementally as an ongoing, evolving process.

**Accountability and Quality Control**

All of the scientists we interviewed explained that with the current emphasis on customers and market-oriented science has come increasing accountability. That is, scientists seem to be coming under ever greater pressure to justify their working practices and the “products” of their research. Here, the views of Gibbons et al. (1994) and Ziman (1996) appear to diverge. On one hand, Ziman warns us of the way in which “privatised,” commercially funded science could threaten the traditional, collectivist values underpinning academic science. In contrast, Gibbons and his colleagues (1994) see Mode 2 as increasing public accountability, social responsibility, and reflexivity.

Significantly, in our interviews, only one respondent raised the issue of intellectual property and the problem of keeping research findings secret. Rather, in discussions about accountability, scientists spoke of their responsibilities to funding organizations and commercial customers as well as to the public more generally. Here again, it is important to note that this sense of
public accountability is not necessarily a recent phenomenon. Indeed, a number of scientists explained how they chose to work in the public sector rather than industry because of their commitment to the environment and their interest in doing “socially responsible” science. They explained, however, that whereas it had formerly been tacit and understated, making this commitment explicit had become an imperative.

Thus, respondents did not suggest that they were in any way adverse to the principle of accountability; they saw themselves as answerable to the public and accepted the scrutiny of their academic and professional peers. And many saw the drive to greater efficiency, which they saw as linked to the issue of accountability, as long overdue.

This organization ten or fifteen years ago was a very different thing. You had people beavering away in little corners, and they just sort of felt that the world owed them a living, and that the tax payer should just give them money and let them get on with whatever they wanted to do. But those days have literally gone forever, I think, and now everybody’s got to chase contract income, they’ve got to win research awards—and I think that is actually very healthy for this organization.

However, while this respondent and others agreed in principle with many of the changes introduced, in his view, they had gone too far:

Some of it was sensible; it’s just the extent to which it went along and the completely blinked dogmatism about it. So that I think there’s a point at which the entire system will collapse; it will just crumble and disappear.

The majority of our respondents strongly objected to being accountable to politicians and managers whose purposes were seen as being at odds with the purpose(s) of their science. Comments generally focused on the level of paperwork that was now required. As explained by one scientist,

We are overaudited by a long way. . . . We end up spending more and more time justifying less and less work because of the amount of effort that goes into it. So that’s our key management challenge at the moment. . . . trying to convince people that the work you are doing is valuable for some national purpose when it may or may not be.

It is important to emphasize that this irritation with the imposition of accountability measures was not exclusive to the more commercially oriented institutions. Scientists involved primarily in strategic, core-funded research explained that they were also required to account for their work on a much more frequent basis.
One of the concerns we have is that there seems to be this huge emphasis on accountability and not enough emphasis on quality science. The reputation [of this institute] rests on the outstanding achievements of the scientists who have come and worked [here] over the years, and the concerns I have is that structures are being put in place . . . that could produce major irreversible effects on our ability to deliver our mission, which is strategic . . . science.

Respondents from one lab explained that although they had few commercial customers, the geographical context in which they worked was politically sensitive, and as a result, the interests of politicians circumscribed much of their work and particularly foreign policy concerns. In that sense, they were not immune from the notion of the “sovereign consumer” (Du Gay and Salaman 1992, 616), which, it is argued, has become “the new overriding institutional imperative” (Keat and Abercrombie 1990, 3). Adapting one’s science to these demands was seen by many as difficult and frustrating; to the scientist, they made little sense in the context of scientific discovery.

An important aspect of accountability is the issue of quality control. Ziman (1996) predicts that “post-academic science will distrust the elitism of peer review and replace or bolster it with quality control of people, projects and performance” (p. 753). Likewise, Gibbons et al. (1994) suggest that whereas in Mode 1 quality is typically assessed through peer review, Mode 2 takes a different approach. Consistent with the principles of applicability and heterogeneity, it is argued that what seems to be emerging is a multidimensional notion of quality whose criteria are intellectual but also social, economic, and political. Gibbons et al. describe this shift quite unproblematically. However, for many of the scientists in our study, it was clearly not so straightforward.

Central in the issue of quality control is a focus on deliverables: what a particular project aims to achieve and how this is articulated to clients. Responses to this change in focus were varied: while some saw it as central to improving efficiency, productivity, and relevance, for others it represented an unwelcome intrusion, a source of tension and frustration, and a barrier to their professional freedom and autonomy. Significantly, this emphasis on outputs appears to have led to a split in the nature of the scientific product. Discovery science was described as culminating in peer-reviewed journals. Conversely, applied research typically leads to project reports for commissioning agents. While academic publications were seen as essential to one’s professional status, the successful completion of commercial outputs was crucial to the organization’s commercial viability and its continued financial success.

Respondents reported a difference in the status accorded to these different products and, for many of them, considerable anxiety as they tried to achieve both. And there was an issue of style. As scientists, they had been trained to
produce a certain kind of output: full of detail, highly technical, and rigorously justified. However, this was not what their customers wanted, and many found it difficult to adjust to these new requirements: “We’re trained to produce a Rolls Royce, but what they want is a Rover.” To some, producing executive summaries and bullet-point recommendations felt like poor-quality science. For others, however, the production of such reports while maintaining scientific integrity represented the development of new and prized capability.

Among the scientists we interviewed, there was a consensus that the setting of scientific agendas, which is symbolized and expressed in performance indicators, processes of accountability, and quality control, should not be a matter for the politicians, managers, or industrialists; rather, scientists themselves must be central to this process. At issue here are questions of professional autonomy and leadership: whose agenda is seen to hold sway, and whose definition of science is seen as legitimate. As one scientist put it, “We’re paid to be experts, and perhaps in that sense, we don’t like being told what to do.” The scientists in our research claim that the role of scientific managers and science policy is to facilitate researchers in the pursuit of their scientific aims and objectives. In those cases where management was seen to promote or to “service” such endeavor, it was welcomed and encouraged. However, when management imposed accountability measures and administrative duties that were not seen as relevant and that did not “fit in” with scientists’ definitions and realities, they were described as inappropriate, burdensome, and potentially destructive.

Discussion

Scientists have a dynamic role in the creation and reproduction of their social world. They are actively engaged in constructing and reconstructing the world around them. We have tried in this article to explore how, in doing so, they “selectively identify, appeal to and skillfully mobilise a diverse set of cultural values” (Willmott 1997, 1333). What we have seen is that the position of scientists as between Mode 1 and Mode 2 modes of science and knowledge production and their relationship to the political agenda depends on a number of intersecting contextual factors. First, as noted elsewhere, it was linked to the nature of the science carried out in their organization and its commercial relevance and funding structures. A second important issue concerned the nature of the individual’s post within his or her institute. For example, those who were taken on as purely contract researchers experienced little tension between these dimensions: they worked on commercial projects, and their performance was largely based on the extent to which they fulfilled the terms of their contracts. At the other extreme, a select number of highly
reputed scientists occupied what were referred to as Individual Merit posts. These posts were awarded to individuals whose scientific achievements were considered to be outstanding and offered “protection” from commercial research, enabling them to pursue strategic science. Those who experienced most tension were those scientists who wanted to engage in cutting-edge science but who were also heavily involved in commercial work and whose status and careers depended on success in each.

The third factor that emerged as affecting how individuals made sense of and positioned themselves within this debate concerned the management style of particular institute directors and their senior teams. It was notable that respondents working for directors who seemed to appreciate the contradictions and tensions implicit in their environment described greater opportunities for negotiation and accommodation. Finally, respondents’ own interests and motivations influenced the way they positioned themselves within the Mode 1/Mode 2 debate. While some respondents were most committed to relevant, useful science, others were driven by their desire to push forward the boundaries of more abstract knowledge and understanding.

Hence, our data reveal that the extent to which science is being constructed as Mode 1 or Mode 2 or somewhere in between these poles varied both across and within the different research institutions. In particular, they highlight how individual research scientists weave their own path through the changing discourses of science, mobilizing relevant aspects of other discourses (entrepreneurship, managerialism) and constructing new understandings and approaches that do not fit neatly into any binary framework.

Our study thus contributes new data to a fascinating, although under-researched debate on changing processes of knowledge production. On one hand, our data seem to confirm current thinking, challenging dualistic frameworks for understanding the relationship between basic and applied research and emphasizing instead convergence and mutuality. However, we also heard a very different story, characterized by an irreconcilable contradiction between basic and applied science and a tension between science budget and commissioned research. In our attempt to cast aside old, outdated dichotomies between discovery and applied science, knowledge producers and knowledge users, and public and private sectors, we must not simply set up a whole other set of binary oppositions: Mode 1 and Mode 2, the old and the new. While such an analysis does provide us with a framework for thinking about changes in the process and practice of knowledge production, as with any typology, it obscures their complexity. It fails to acknowledge the different structural positions that research establishments might occupy in relation to these changes, nor does it account for the ways in which they are constructed by individual research scientists themselves.
There is often a tendency to focus on disjuncture, on breaking with the past and on establishing new ways of thinking and doing. While we see the Mode 1/Mode 2 model as a useful heuristic device for understanding the ways in which conceptualizations of science are changing, it is important that we also examine those processes, practices, and discourses that have endured. Indeed, several of the participating organizations had long histories and traditions, and a strong sense of being part of those traditions permeated by scientists’ accounts. Thus, in attempting to make sense of the changing context of public sector science, we must also be mindful of things that have stayed the same. Nevertheless, it does appear that relationships between knowledge producers and consumers—whether they be private sector, public sector, academics, industrialists, or society—is a dynamic process. It is in this area that further research is needed to enhance our understanding of how scientific knowledge is produced and how to best organize this process.

Note

1. In the case of the research council to whom our participating organizations are responsible, these include terrestrial, marine, and freshwater biology; Earth, atmospheric, hydrological, oceanographic, and polar sciences; and Earth observation.

References


Laurie Cohen is a lecturer in human resource management at Loughborough University Business School in England. Her current research interests include the changing contexts of professional work, focusing on public sector scientific research establishments. She has also published in the area of career transition and the emergence of new career forms and patterns. Central to her work is an interest in language and sense making.

John McAuley is a professor of organization development and management at Sheffield Hallam University in England. His special areas of interest are organization behavior and development, change management, and consultancy. He has researched and published in the area of professional organizations. His consultancy work has been wide ranging and mainly in public sector organizations. For many years, he was a tutor for management development programs within the Health Service and has also worked on management development programs for research councils and the Civil Service.

Joanne Duberley is a lecturer in human resource management and organizational behavior at Sheffield University in England. Her research interests include the changing nature of professional organizations and the management of strategic change.