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INTRODUCTION

Revisiting Mode 2 at Noors Slott

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In November 2009, at Noors Slott in Sweden, a small group of distinguished individuals from academia and government met to reflect on the ideas developed in the New Production of Knowledge (Gibbons et al., 1994) and Re-thinking Science (Nowotny et al., 2001). The aim was less to determine the impact of these works on science and policy than to identify what, if anything, the authors had overlooked or, indeed, what developments had occurred during the past 25 years that might alter the conclusions reached in these two books. The purpose of this introduction is not to provide a summary of each paper, but rather to present some of the key elements that emerged in the discussion, configured to point to future questions which science policy researchers might address. Five areas have been identified within the overall Mode 2 theme: bibliometrics; regime change; the role of laboratory spaces; open innovation; and the politics of innovation.

Some evidence of Mode 2: bibliometrics

The authors of the two books under discussion have often been asked what their impact has been. To be sure, the notion of Mode 2 as a new form of knowledge production has received its fair share of both support and criticism. That is only to be expected, particularly in an academic environment. However, the most generic concern has simply been for evidence of this new mode of knowledge production. Some (albeit limited) evidence has been adduced from researchers in the field of bibliometrics and is reviewed by Martin in his paper.

In his presentation at Noors Slott, Martin elaborated upon a fascinating dynamic in the pattern of authorship in discipline-based journals when new issues emerge. Here, scholars and others from different fields and areas of expertise do indeed find a voice. One interpretation of this is that there is a time period, even in the specialised literature, when it is open to ‘outsiders’. After a time, however, the issue seems to be captured by those more closely identified in the particular field. Then, the outsiders tend to disappear and authorship returns to equilibrium, with ‘insiders’ contributing papers on the original issue. From this behaviour, it seems that knowledge production within a field might oscillate between Mode 1 and Mode 2 forms. To summarise the differences between the two modes: in Mode 1 problems are set and solved in a context governed by, the largely academic, interests of a

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specific community. By contrast, Mode 2 knowledge production is carried out in a context of application. Mode 1 is disciplinary while Mode 2 is transdisciplinary. Mode 1 is characterised by homogeneity, Mode 2 by heterogeneity. Organisationally, Mode 1 is hierarchical and tends to preserve its form while Mode 2 is more heterarchical and transient. Each employs a different type of quality control. In comparison with Mode 1, Mode 2 is more socially accountable and reflexive. It includes a wider, more temporary and heterogeneous set of practitioners, collaborating on a problem identified in a specific, localised context.

Martin concludes, admittedly somewhat cautiously, that bibliometrics, as a field of research, has exhibited a shift towards Mode 2 knowledge production over the last two decades or so. In addition, bibliometrics would seem to have played a significant part in this shift, contributing policy-relevant tools and analyses, helping scientific research to adjust to some external accountability, and contributing to changes in the approach to the quality assessment of research.

It is incontestable that, over time, the number of authors contributing to scientific papers has increased, as have their institutional affiliations. As the bibliometricians have adduced, the wider participation of researchers who, strictly speaking, are not members of a particular discipline, is an indication of increasing multidisciplinarity and perhaps even of an increasing porosity of the disciplinary structure of science. In some respects, then, this and similar research offers some (albeit limited) evidence of the existence of a new mode of knowledge production.

Although there may be some evidence of the growth of multidisciplinarity in research in the notion of transdisciplinarity put forward as one of the key characteristics of Mode 2, many scholars remain less convinced. It seems that some find it difficult to imagine, or even acknowledge, that, in some cases, genuine path-breaking theoretical insights can emerge in groups of individuals working beyond established disciplinary boundaries.

Regime change

Describing what has been going on in various national institutional frameworks for organising research, Rip has proposed that, over the past 20 years, a new institutional framework has emerged, one different from that which was put in place after World War II, a regime of 'strategic science'. According to Rip,

> ... a regime comprises a broad framework in which research is funded and performed. A regime can be used to identify, at the system level, the arrangements that channel social, economic and political objectives through the mechanisms for research funding and on to the institutions – universities, government laboratories and industrial R&D laboratories – which actually carry out the research. As such, a regime is less a system of rules about how research should be conducted and more a description of how those rules are applied, though these two strands are often inter-twined.

This complex of arrangements, once established, enjoys considerable stability. Attempts to introduce major changes can be expected to experience strong counter pressures, particularly from practising scientists in universities and government laboratories, to maintain the *status quo*.

Such a regime grew up in the period immediately after the Second World War and continues to flower as new disciplinary specialisations emerge. It is labelled the regime of 'basic science', though it has always included technological research as well as research in the human and social sciences. A principal element of this regime has been a rapid growth in financial support for scientific research from central governments, both in its own laboratories and, particularly, in universities. It was during this regime that the universities completed their transformation into leading national research institutions. Government laboratories, in contrast, have always tended to structure their research agendas under broad economic and political headings – energy, mining, public health, etc. – but it has always been possible for scientists in these institutions to apply for research grants, sometimes in collaboration with university scientists. Nonetheless, the establishment of the regime of basic science was aimed primarily at supporting research in universities and producing a cadre of trained researchers.

During the regime of basic science, budgets increased across the board, but the allocation of funds to individual research programmes was left more or less in the hands of recently formed research councils and government research establishments, some with very long histories indeed. In this institutional setting, the research agenda was determined to a large extent by scientists through peer reviewed research applications, and carried out in either university or government laboratories. It was tacitly and generally assumed that this research would, at some time in the future, lead to new product and process innovations in industry, better health outcomes and a stronger economy.

In sum, in return for funding and a degree of intellectual freedom, science would provide a continuing boost to the social and economic well being of the nation. To some extent, this was all intended to happen automatically, but at some unspecified time in the future. No one doubted that, in general terms, the regime of basic science would lead to social and economic improvements, and that more research meant a greater number of these improvements. However, the mechanisms through which this process might operate were regarded as, at best, indirect. More practically, along the way, the universities would be providing a flow of scientific talent to work in a range of social contexts, but principally industry. In particular, the linear model of innovation became institutionalised in the regime of basic science. It took hold institutionally and intellectually and, despite its obvious oversimplifications, it has remained a latent mainstay of science policy from its beginnings to the present day.

This complex set of institutions – government, industry and university – and social roles and rules which bind them together constituted a regime which has enjoyed remarkable stability over many years. Still, the rising costs of research and demand for the training of more and more postgraduates – M.Sc. students, Ph.D. and postdoctoral researchers – has, in turn, led to the elaboration of a career structure for researchers and increased the numbers able to apply for research funding which, in turn, has put pressure on funding budgets.

These developments encouraged many to ask whether the route between research and its social application ought not to be made more transparent and direct. Indeed, subtly over the past 20 years or so, governments in many countries have attempted to initiate change by trying to tie research more closely and explicitly to specific social and economic priorities. These changes lie at the heart of a new regime, labelled here the regime of ‘strategic science’. As the papers presented at Noors Storr indicate, the effort to link science more closely to socio-economic goals has met limited success. So, it might be argued that the outcome has been not so much a new regime as a modified regime of basic science. On this reading, it seems that despite sustained political, social and economic pressures, the regime of basic science has weathered the storm and modified the behaviour of scientists only minimally and then at the periphery.

Nonetheless, it is the case that the past 20 years have seen an increase in the bureaucracy that manages the allocation of research to universities. In particular, a new layer of university managers has emerged to facilitate the writing of research grant applications and oversee performance through to the end of the grant. Now, deans, directors of research schools and technology transfer agents flourish among the practitioners of science and industry. Whether these changes are significant enough to amount to regime change, remains, for some, an open question.

Historically, such change as has occurred has been driven by changes in government policy which have induced institutions to accommodate themselves to different ways of obtaining research funding. The hope was that some scientists, in particular, would engage with policy objectives and modify their research agendas. However, there remains some suspicion that little more than non-trivial mutual accommodation among government, universities and practising scientists has actually taken place. Rip draws empirically on the experience of universities that have established research centres. However, the number of these remains small. It is not clear whether these developments are sufficiently robust to constitute a new regime rather than a pragmatic response to short-term economic and political exigencies. To be sure, Rip is correct in pointing out that, if the trend towards setting up university-based research centres continues, the universities cannot remain as they are, organised around the disciplinary structure of knowledge and scholarship.

The notion of a regime is helpful in contextualising the papers by Cozzens and by Halliwell and Smith, with their references to emerging systems of science, technology and innovation (STIs). In the most general terms, these papers do describe the shift, in various countries, from basic science to strategic science, and it is tempting to see this in terms of regime change. The policy changes described empirically by these authors, though they do not explicitly use the language of regimes, suggest that it would not be difficult to set their presentations in that framework. Clearly, some mutual accommodation among government, the institutions of science and scientists has taken place in the past 20 years, but how deeply the ethos of the regime of basic science has been affected is more difficult to discern. In addition, Rip has used the notion of regime change to posit the emergence of a new type of university, a postmodern university (see also Rip, 2008). What is required in both cases is some evidence that the rules of the game really have changed and that a different sociology of science, including its reward structure, has emerged, or is at least beginning to emerge.

A further indication of the complexity of current arrangements, and hence the possibility of regime change, can be found in an incisive paper by von Tunzelmann (2009), which traces the evolution of industrial economies over the last 150 years. Von Tunzelmann (2009, p.358) has noted what he describes as 'contemporary shift' in policy across countries and regions. He argues that:

> … [in] the particular policy mixes adopted by governments within and without regions … (t)he main drivers are increasing complexity (in technologies and markets, etc.) and increasing globalisation (via competition and collaboration). Interactions within government are required to prepare 'joined up policy' to meet these complex demands – what might be called an 'internal alignment' of the policy mix. In practice, we observe chaotic mixes of policies and policy makers, not least in countries such as China and South Korea that are heading many of these new developments, alongside repeated attempts to improve policy structures and policy learning therefrom.

It is possible that regimes of strategic science will emerge first in these countries, in part because the regime of basic science has never become as deeply embedded in the organisation and ethos of research as it has in the universities in the Western world.

Perhaps, then, it is too soon to pass judgement on whether substantial regime change has so far occurred, but if von Tunzelmann is right, profound changes are already taking place in the modes of funding and research collaboration to cope efficiently with the development of the new technology clusters that underpin competition. For example, in relation to knowledge production, von Tunzelmann contrasts a supply side view (old fashioned, linear) with a more complex dynamic, which, in addition to published knowledge, includes knowledge gained through doing, using and interaction (DUI). Does this incorporation of a wider array of knowledge inputs not suggest the emergence of new forms of knowledge production? Learning by doing, using and interaction might well describe the way knowledge is generated in the laboratory spaces described below.

Perhaps research is becoming more like Mode 2 because of globalisation and the increasing complexity that accompanies globalisation. If so, research policies will be determined by a far wider range of considerations than have been evident so far in the development of strategic science. This has been characterised by each country mounting its own set of strategic research priorities and projects in the hope of outstripping others industrially and economically.

Despite the growing complexity noted in the papers presented herein and in the detailed research of such scholars such as von Tunzelmann, it still seems that many scientists, if not their governments, are *de facto* still working mainly with a linear innovation model in which science provides essential inputs to technological development that drive innovation and economic growth. The current situation has been well characterised by one senior science administrator (who had better remain anonymous) who observed that we are going to be hung by our own petard: in our science policies, we have promised everything and delivered nothing beyond more science. This unhappy interpretation of the past 20 years of science policy raises the question of whether and how deeply the regime of basic science has been altered. On that judgement depends whether one can say there is sufficient empirical evidence to indicate that genuine regime change is occurring.

In sum, government science policies which use the rhetoric of strategic research are now well established in many different jurisdictions, though it must be said that, in every case, a substantial tranche of funds is still preserved for recognisably traditional ‘pure’ research. From our perspective, the question is whether regime change – the shift from the regime of basic science to the regime of strategic science – has any isomorphism with a shift from Mode 1 to Mode 2.

Laboratory spaces

Of all the concepts to which we are introduced in the *New Production of Knowledge*, the most difficult to communicate has been the context of application. Among scientists, it rings alarm bells about a shift from pure to applied science. This interpretation immediately undermines any further consideration of the meaning we intended. Resistance has been particularly strong in countries where the lobby for the independence of Mode 1 research is strongest. For example, a recent defence of Mode 1 in the university context comes from J.R. Cole of Columbia University, who argues that the great American research universities are being starved of funds for research, which will undermine the intellectual pre-eminence of the research universities, cause researchers to migrate to other countries, and erode America's economic strength and political power (Cole, 2009). For Cole, university research is, and should remain, in Mode 1, governed entirely by the internal dynamics of science itself and located in a university setting. The case is passionately argued and replete with warnings of the dangers of not adequately funding the greatest universities. How to engage with this argument and open minds to the possibilities of alternative organisation?

One idea which is latent in our work has been suggested in *Reinventing Knowledge: From Alexandria to the Internet* by Ian McNeely and Lisa Wolverton (2008). The authors discuss, among other things, the history of the development of the disciplines and draw attention to their latter day transformation, particularly, but not only, by the increasing dominance of the experimental laboratory in both the natural and social sciences. For McNeely and Wolverton, laboratory space is the engine room of scientific productivity. It is not only the context in which theoretical ideas are elaborated, put into practice and tested, but also where practical arrangements often suggest new theoretical possibilities. They cite NASA as one typical, and very effective, example of a laboratory space.

As described, a laboratory space resembles a craft environment and is by definition a dynamic environment in which theoreticians, technicians, experimentalists and, increasingly, public voices – government officials, pressure groups and individuals – collaborate to solve problems using scientific methods. A laboratory space is the locus of a dynamic conversation among many parties. It is not so much a home for multidisciplinarity as a crucible in which many different languages and traditions are synchronised, so to speak, to solve problems and perhaps also create something theoretically novel. Though McNeely and Wolverton do not develop these ideas, what they do write about is not very far removed from what we meant by the context of application and transdisciplinarity in *The New Production of Knowledge*, and by the development of transaction spaces and trading zones in *Re-thinking Science*.

The development of the laboratory, as McNeely and Wolverton put it, would seem to be a harbinger, perhaps the harbinger, of the growing predominance of Mode 2 knowledge production, though they do not use this language. Laboratory spaces can threaten established institutional structures, not least the discipline-based science that is housed within universities. Further, they argue that the universities will be left behind if they fail to open themselves more fully to the ethos of laboratory space. As McNeely and Wolverton describe it, the laboratory is already the womb of discovery and its form is pressing on the traditional universities and other institutions of science and technology to adjust. Surprisingly, they conclude that institutions (meaning universities) can accommodate the laboratory concept by making mid-level organisational changes (for example, more research managers and deans) that need not threaten the viability of universities or the scientific institutions themselves.

Randolph Bourne argued many years ago that laboratory spaces would transform universities. Bourne declared that 'the issues of the modern university are not those of private property but of public welfare', and that 'irresponsible control by a board of amateur notables is no longer adequate for the effective scientific and technological laboratories for the community that universities are becoming' (cited in Cole, 2009, p.352), While Cole quotes Bourne, he does not seem to realise that these 'laboratories for the community' need not be based in universities at all. However, if they do flourish in this context, the universities cannot remain unchanged.

The idea of a distinct laboratory space with an ethos of its own requires a shift of perspective in which the laboratory is the site in which theories are developed in consonance with a range of factors that are meant to test them. To assume the precedence of either one over the other simply misses the point that the laboratory space is itself the fundamental incubator and driver of scientific advance, and that its walls are porous. Clearly, there are similarities between the context of application and the transdisciplinarity that it promotes, and laboratory spaces. The notion of laboratory space gives these characteristics of Mode 2 a temporal and spatial existence, and makes them more concrete.

The development of laboratory space as the organisational form in which contemporary research is carried out may well weaken the hold of universities as the primary source of scientific creativity, a belief which is deeply rooted in the ethos of the modern research university. (Again, Cole worries about this point.) Laboratory spaces are expensive, difficult to manage and, perhaps most importantly, transient. As has been recently seen, the American shuttle programme is now drawing to its close. Many laboratories devoted to specific problems do not have disciplinary advancement as their objective, and often work on shorter timescales than universities, with their ethos of tenured faculty. University laboratories can be slow to respond and may no longer be able, on their own, to dictate the rate and direction of scientific research, or raise the funding needed to operate at the forefront of research.

Part of the difficulty of changing the prevailing ethos in universities is sociological. The days when a young Ph.D. student would proceed to her doctorate, take a couple of research fellowships (usually following up work done in the Ph.D. with the aim of developing sufficient scientific credibility to apply for grants in his/her own right), set up her own laboratory in some university department, then recruit a few doctoral students who will repeat the process during their careers may now be over. If so, this may imply a regime change far more profound than the relatively modest expansion of university management to cope with the advent of strategic research policies in the 1980s and 1990s. Are the pressures for such regime change now irresistible? If they are, is this because the laboratory space has wrestled itself free from university and government laboratories and, through complex funding packages involving many different types of organisations, taken on an independent life?

Perhaps it is in the environment of the laboratory spaces that the contemporary demand for interdisciplinary research will reach its full development. Freed from the university departmental structure – but maybe not entirely from universities – laboratories will be able to follow research lines wherever they may lead, and draw in whatever financial resources and skills are needed to work unhindered by teaching, recruiting practices and the thousand and one pressures that academics have to face daily in maintaining their departments. It is perhaps in laboratory spaces that the dictum of Louis Menand (2010) may finally come to pass: ‘Interdisciplinarity will not come about by bringing knowledge producers together but by changing the way in which knowledge producers are trained’. This is precisely what the environment of a laboratory space will do. Who will do it and how will it be done are further questions, but these issues could be resolved beyond the walls of the research universities.

For example, it could be argued that young scientists trained in the environment of a laboratory space will make their way in science in accordance with the ethos and rules of their particular laboratory. This ethos will be distinctly problem-riented and will make use of whatever scientific skills are deemed necessary. It should not be necessary to repeat here that a problem-oriented approach to research is not applied research because there is, as yet, no research to be applied! One consequence of this new environment may be that scientists will not be judged entirely in terms of their contribution to their disciplines, but also by their contribution to the goals of the laboratory. This is bound to weaken traditional disciplinary loyalty, even as it allows interdisciplinarity to flourish. In other words, laboratory spaces will become the natural habitat in which knowledge producers are raised, the very environments which Menand has indicated are so essential for the growth of robust interdisciplinary research.

Another important point is that laboratory spaces may exhibit considerable diversity (depending upon the problem being addressed) and this diversity will demand something like a floating population of expertise hired according to need. In this context, careers will mean something different from what has traditionally promoted advancement in a university setting. Perhaps alternative forms of peer review will emerge.

To return to the beginning, perhaps it is the particular problem orientation of a laboratory space that gives substance and structure to the context of application that was introduced in our discussion of Mode 2 research. A laboratory space provides the orientation and the context that determines how a particular problem will be addressed, and these need not be those of a particular discipline. The context of application makes use of whatever research is necessary to clarify or solve a particular problem. Such a context need not have any narrow technological, economic or social goal, though it might. Research on problems defined in a particular context is judged entirely by the extent to which it clarifies or throws some light on the problem in question. Implicit in this argument is that laboratory spaces may not be funded primarily by governments. Finance, particularly support from industry and endowments from a growing number of private foundations and wealthy individuals, may well provide the initial and perhaps even long-term funding of independent research institutes.

Von Tunzelmann (2009) has provided a robust criticism of the McNeely and Wolverton book. One of his criticisms might just as well be applied to our own work. His point is that if one is going to proclaim that a new mode of knowledge production has emerged, it should be possible to say where the old one ends and the new one begins. McNeely and Wolverton have not done this, but neither have we – perhaps because we do not see Mode 2 entirely replacing Mode 1, but rather existing in some relationship with it. Still, the point is well made.

However, von Tunzelmann (2009) saves the sharp edge of his critical remarks for the way in which McNeely and Wolverton have played down the importance of the Internet in contemporary knowledge production, allowing it little role in the new production of knowledge. Perhaps the principal reason for this stance lies in his own attempts to understand the long waves (Kondratief cycles) that have emerged since industrialisation began in the early nineteenth century. In the twenty-first century, he argues, computing and telecommunication technologies will constitute a major cluster and it will be based in China and south-east Asia. Irrespective of the existence of Kondratief waves, one tends to agree with von Tunzelmann and his concern about the lack of importance that McNeely and Wolverton give to the Internet. As we have argued, the Internet and the informal modes of communication which it stimulates can create informational environments – transaction spaces, perhaps – which over time can evolve into more formal laboratory spaces without walls, spaces which have been identified as a seed bed of knowledge clusters. Not least in this regard is the role that the Internet is already playing in open innovation systems, which seem to thrive in the spaces both within and in-between firms – a subject to which we now turn.

Open innovation and Mode 2

Open innovation links naturally with the idea of laboratory spaces. It is a view of innovation that assumes that firms can and should use external as well as internal ideas, and exploit internal and external paths to market, as they seek to develop their technologies, products and processes. Open innovation assumes that the boundaries between firms and their environments have become more permeable simply because it is necessary to keep ahead in the innovation process. The central idea behind open innovation is that in a world of widely distributed knowledge production, companies cannot afford to rely entirely on their own research. Instead, they actively seek to buy or license processes or inventions from other companies. In addition, inventions that are not being used in a firm's business should be actively promoted outside the company through licensing, joint ventures and spin-offs. This is a description that accords with von Tunzelmann's view about what is happening in the universe of global competition and collaboration, of technological clusters and innovation described above.

While it may be said that, in outline at least, Mode 2 anticipated the notion of open innovation, it was never developed beyond the formation of external partnerships of various kinds. The last decade has seen a fuller articulation of the nature of open innovation in emerging technologies, which shows that the timing, range and scope of external contributions to innovation depend crucially upon each company's 'differential position within the innovation system in question, the nature and stage of maturity of the technological regime, and the particular value proposition (or business model) pursued by companies' (Christensen *et al.*, 2005).

The more open modes of knowledge production, which we had already identified, were, admittedly, rather general in nature. As regards open innovation, however, we did not so much miss this development as not articulate it as fully as we might have done. In a sense, this was regrettable because there are obvious overlaps between Mode 2 and open innovation to which attention might have been drawn. For example, in his paper in this issue, Alan Hughes provides a chart of the range of problem-solving activities in which university staff were involved in 2009. Perhaps surprisingly, his data show that academics typically participate in open innovation activities of various kinds: namely, external secondment, research consortia, joint research projects, and contract and consultancy services. One possible measure of the advance of Mode 2 would be to collect similar data over time. This might allow some conclusions to be drawn as to whether Mode 2 is becoming an increasingly important aspect of open innovation.

Contrary to popular rhetoric about the isolation of universities from the industrial environment, Hughes shows that many academics have a wide range of interactions with external organisations. In fact, many actually report their research to be user-inspired basic research or applied research, and disclose a wide range of interactions with external organisation. Resorting to the latest jargon, Hughes observes that academics 'are very "connected" individuals in "connected" universities'.

In his concluding paragraph, Hughes calls attention to the policy challenge of 'developing effective Mode 2 relationships in the UK and the capacity to exploit the opportunities of increasingly open models of business innovation'. He observes that it 'requires structures of funding and organisational forms which enhance the "public space" roles which encourage the reflexive interplay between the commercial and university sectors and which avoids a simplistic distinction between applied and basic research in key resource allocation decisions'. It would be interesting to compare Hughes's notion of public spaces with the characteristics of laboratory spaces just adumbrated.

The politics of innovation

Much of the literature on science and technology policy has been variously concerned with high level structures – regimes, national innovation systems, Mode 2, quadruple helix and perhaps even Mode 3 forms of knowledge production. All of these are general ways of describing very complex sets of arrangements. Not infrequently analysis has focussed on relations among universities, industry and government, all regarded as organisations with relatively impermeable boundaries. Rip's theory of regimes brings in broader sociological factors that organise the rules of the game, rules which operate in any system of institutional arrangements and which serve to give innovation systems their stability. As indicated above, regime change implies a shift in the rules of the game; for example, in the reward structure for scientists who take on the challenges of setting up centres of excellence. Rip's paper provides an example of this in describing how a centre of excellence in nanotechnology came to be established at Twente University in the Netherlands. His analysis, far from subverting the notion of Mode 2, throws additional light on its relevance as an emerging form of knowledge production.

Still, critics and supporters alike have construed Mode 2 as a form firmly rooted in the discourse on the economics of innovation. For example, the double helix form of knowledge production adds to science, technology and economics explicitly cultural and political factors, while Mode 3 attempts to unite Mode 1, Mode 2 and double helix using the framework of system analysis. It is argued that these higher integrations are necessary given current concerns over the environment and forms of energy production, exotic medical procedures, and so on – all risk factors influencing the formation of science policies and altering the practice of research itself. Now, many more participants are involved and these coalitions of interest are driving greater diversity in science policy approaches to a range of social and economic problems. As Stirling (2007) has argued, in this emerging regime, scientific and technological questions are not just 'Yes or no?', 'How fast?', 'Who leads?'. Rather they are 'Which ways?', 'Why?' and 'Says who?'.

This change in the focus of innovation policy has come about through pressures from civil society to broaden the range of factors influencing scientific and technological choice. The civil society movement has brought pressure on governments, and parallels the more general emergence of monitory democracy described in *The Life and Death of Democracy* (Keane, 2009). Keane argues that the development of monitory democracy can catalyse a new politics of innovation which may have a global dimension and affect both the rate and direction of technological change.

Stirling (2007) has noted that science and technology policy is shifting technologically from lock-in (we must do this and do it quickly) to diversity; and socially from the economics of innovation to the politics of innovation. He found many different reasons for increasing interest in diversity, not least in high profile areas of science and technology policy. Diversity offers a means to promote innovation, hedge ignorance, mitigate lock-in and accommodate pluralism. It offers one important strategy for achieving qualities of precaution, resilience and robustness that are central to sustainability.

Stirling's analysis provides a framework within which to develop a politics of innovation in a range of different contexts. Policies will need to be developed which are sensitive to the demands of civil society, a sensitivity that could reach into the heartland of scientific choice, where problems are formulated and funding sought. That governments have little idea about how to generate policy instruments in this kind of environment would not be contested. Will a shift from the economics of innovation to the politics of innovation lead to new modes of production something like Mode 2 or Mode 3 (Carayannis and Campbell, 2009)? It is worth remembering that the institutions of science which control Mode 1 types of science are well established and are understandably conservative. Indeed, they are well versed in absorbing pressures of various kinds without undergoing fundamental change. A key question is whether pressures from civil society will make it all but impossible to retain the basic criteria for scientific choice.

Conclusions

So, what has been learned from the Noors Storr meeting? In particular, what might we have overlooked in our previous work? In retrospect, we do not believe anything of significance was overlooked, except perhaps to underestimate the staying power of the major institutions of science. It would be interesting to do a more in-depth analysis of the hypothesis of a regime change from basic science to strategic science because, in our view, Rip's analysis, far from subverting the notion of Mode 2, throws additional light on its relevance as an emerging form of production.

It is doubtful, however, whether such a study would throw much additional light on our original analysis of Mode 2.

At a more detailed level, it may be that we overlooked the importance of privately or semi-privately funded research institutes for science in general, and for universities in particular. These are increasing in number, at least in the United States, and it seems that they are still a long way from being comfortable within a traditional university context. Private funding of research institutes in universities is already problematic, so much so that it is now established wisdom among university presidents that research institutes are a short-term gain and a long-term pain! Because we did not target research institutes specifically, we may have overlooked the opportunity to consider more closely whether they constitute important but different types of laboratory space from the research institutes which operate exclusively within the walls of most universities.

It is still an open question whether research institutes will function increasingly as centres of scientific and technological innovation not just outside the university, but also beyond the disciplinary structure of science? Will they become the transaction spaces and trading zones that we tried to describe in *Re-thinking Science*? Will research institutes soon take on responsibility for training their staff and provide alternative career paths for those who want to stay at the leading edge of research? Are research institutes irremediably transitory things and, if so, what of the careers of those who spend their most research-productive years in them? Will independent research institutes flourish only in the richest countries of the world, where resources that are privately held can sometimes outstrip those available from central governments in specific areas? To what extent can private funding really displace the current near-monopoly of government in the funding of science in top universities? These are further questions still to be addressed and further questions in any research are not uncommon. This is not to be regretted; as the economist Thorstein Veblen (1919) observed many years ago: 'the outcome of any serious research can only be to make two questions where only one grew before'!

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