Management of Basic Research and Development: Lessons from the Australian Experience[1]

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ABSTRACT *Management of science and related basic research and development by the state is not a new phenomenon. In this paper it is argued, on the basis of recent Australian experience, that the conventional approach which assumes that the research community is a simple system is deeply flawed. Specifically, it is argued that any pattern of government funding which assumes linear relationships between funding and scientific outputs is unlikely to be productive. Further, it is suggested that a quantitative approach to research management is counter-productive to innovation. A range of ideas is used in developing a more productive set of policies for basic research and development.*

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The management of science by the state is not a new phenomenon. Indeed, the origins of scientific endeavour being directed towards public benefit can probably be traced back as far as the 17th century in the literature of Francis Bacon. The potential effects of a well-directed science policy are so great that governments of all types seek to control research in a quest for innovation and political or economic survival. As Van der Muelin and Rip[2] observe, 'government funding of research has always been limited to the socio-economic relevance of research'. This applies irrespective of government ideology and despite admitted differences in national styles of science funding.

Consider the following two statements. The first is by Michael Polanyi, writing about the impact of Stalinist ideology on basic scientific research in 1930s Soviet Union:

> I first met questions of philosophy when I came up against the Soviet ideology under Stalin which denied justification to the pursuit of Science. I remember a conversation I had with Bukharin in Moscow in 1935. Though he was heading toward his fall and execution three years later, he was still a leading theoretician of the Communist party. When I asked him about the pursuit of pure science in Soviet Russia, he said that pure science was a morbid symptom of a class society; under socialism the conception of science pursued for its own sake would disappear, for the interests of scientists would spontaneously turn to problems of the current Five-Year Plan.[3]

The second comes from recent analysis in Australia, a liberal democracy apparently in the mainstream of the general move in the global economy towards deregulation and 'economic rationalism':

> The ongoing obsession with national priorities, guidelines and coordination which imbues educational, research and technology pronouncements is a strange paradox in a society in which its economic affairs emphasise deregulation and market

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> orientation. In the case of universities, there appears to be little appreciation on the part of the commonwealth bureaucracy of the intrinsic mission, culture, values and workings of the institutions, nor of what motivates their academic staff.[4]

In both cases governments have assumed that innovative research will follow government funding of science. Such assumptions are based upon a relationship between basic scientific research and the national innovation system known as the linear model. This paper argues that there are two related flaws in this model.

The first is that it uses an unrealistic and simplistic view of organisations. Instead, we suggest that organisations and groups of organisations are better looked on as complex systems in which the relationship between inputs and outputs is unpredictable. The second flaw is even more basic: the linear view taken by governments seeking to control and further scientific research is based on a quantitative view of research, one that is based on the measurement of tangible inputs and outputs. The simple model of organisations and quantitative approaches are both part of the modernist project that attempts to '... develop objective science (and) universal morality and law ...'.[5] The idea is to use rationally structured organisations and forms of thought in order to enhance society, the very essence of what de Solla Price called 'big science'.[6]

The argument proceeds in three stages. We begin with a brief consideration of the recent history of research funding in Australia, concentrating on the key area of Higher Education funding, in order to indicate the struggle that the Australian Government has had in trying to link research to perceived national needs. The perils of using a simplistic view of the research system and the organisations within it are then discussed before consideration of the related and fundamental problems of a quantitative approach to controlling research.

Australian Higher Education Research in the 1980s and 1990s

The general pattern has been one in which funding was linked to national purposes. A range of government actions from 1980 to 1994 demonstrate this. Garrett-Jones *et al.*[7] list 15 separate major government initiatives to this effect taken between 1980 and 1994, including a major reconstruction of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), various attempts at science priority setting and attempts to develop indicators for academic research. This pattern of policy making is one which demonstrates continued affirmation of the importance of knowledge and research while at the same time seeking to control and direct it. This is perhaps most evident in the significant higher education sector in the late 1980s and early 1990s.

With the release of a White Paper on higher education in 1988, the Australian Government commenced a sustained process of policy development and structural reform in the higher education sector. By the issue in May 1989 of its Science and Technology Statement, the Australian Government had established the policy directions which were to serve as the foundations for its programme of radical change to the higher education system and the management of research.

The Australian Government's published motives for wishing to enhance the research effort in the higher education system were to 'encourage fundamental inquiry for the advancement of knowledge; to develop skills in analysis, interpretation and problem solving; to enhance the national scientific and technological capacity; and to create and maintain a reservoir of expertise which may be applied to problems and opportunities that may face the nation'.[8]

Emphasising its intention to sustain a strong basic research commitment across all

disciplines, the Australian Government moved after the White Paper phase to implement three particular aspects of research policy. First, the so-called 'binary' system which divided higher education institutions into two classes—one specifically funded for research and teaching (the traditional universities) and the other specifically funded for teaching only (the former colleges of advanced education)—was abolished, thereby increasing the number of institutions defined by their research aspirations.

Secondly, the Australian Government implemented a levy on the operating grants of the pre-1987 universities for the purpose of providing funds to the new Australian Research Council (ARC). These funds were then to be allocated by the ARC through a competitive grants scheme to which all universities, including the former colleges of advanced education, could apply. The ARC was established as one of the four councils of the National Board of Employment, Education and Training (NBEET), and given responsibility 'to make recommendations to the Minister on the distribution of its research support budget; and to inquire into, and provide information and advice to the NBEET on a broad range of research policy matters, such as research priorities, the coordination of research policy, and measures to improve interaction between the different research sectors in Australia'.[9]

Thirdly, the development of management plans and the regular provision of detailed statistical information on their research activities, became a prerequisite to the negotiation of every university's educational profile with the Department of Employment, Education, and Training. While declaring its intention of not dictating the content and format of Research Management Plans (RMPs), along with acknowledging that each university's RMP would reflect its particular history and mission, the Australian Government expressed the view that RMPs should establish the strategic parameters for a university's research, as well as open up to external scrutiny the processes by which government resources were allocated to achieve its stated research goals.

Universities criticised the introduction of the research profiles concept as an unwarranted attempt to constrain and alter the whole basis of research management within universities. The Australian Government responded that the quality of research management within universities needed significant improvement if greater selectivity and concentration, and hence improved research productivity, were to be achieved. It argued that the considerable autonomy held by universities carried with it the responsibility for efficient management and the research profile mechanism was the means by which universities were to be made publicly accountable for their management practices.[10]

The establishment of Co-operative Research Centres (CRC) and incentives through the ARC for research collaborations between industry and research bodies arguably provides some balance to those moves. The aim in establishing CRCs focused on particular areas of research was to create linkages productive of innovation between research bodies and between research and industry.[11]

These two initiatives represent a significant variation on the historical pattern of university related research funding in Australia because they emphasise collaboration and linkage with industry. They still, however, reflect an approach which suggests that there is a direct measurable connection between monetary input and output. Accountability for research outcomes measured using conventional quantitative indicators is still fundamental to these initiatives and is legitimated by the bureaucratic culture of managerialism underpinning the CRC scheme.[12]

There can be little doubt that the policy initiatives and process of structural reform caused alarm, mistrust, and determined opposition across the higher education system. As suggested earlier, it raised some fundamental questions about the nature of scientific research and the applicability of certain management techniques to science in the

organisational context of a university. We suggest that the basic flaw in the Australian approach is to assume that organisations are simple systems in which outputs produce predictable inputs. The following discussion points out the errors that resulted from this.

Research Organisations—Complex Systems and Culture

Organisations can usefully be viewed as complex systems in which actions have unpredictable consequences.[13] In this view they are non-linear feedback systems in which the actions of people and groups are based on current perceptions which, in turn, are affected by personal and organisational history and culture. This means that the responses to action at individual and organisational levels are non-proportional, that is, they are either under- or over-reactions to the force applied. Examples of the consequences of this abound. A minor unintentional remark about someone's style of dress may offend a friend of the person with the result that an idea is rejected at a subsequent committee meeting and a policy therefore fails to be implemented. On a grander scale, the 're-engineering' of an organisation may be undertaken in order to increase organisational flexibility and responsiveness. This may include reduction in the number of layers of management, the introduction of complex computer systems that operate beyond the skill level of workers and the 'outplacement' of many workers. The unintended consequences of policies such as these in the early 1990s were fear and resentment in remaining workers and loss of corporate memory—when many people who held important knowledge were made redundant.

Such unpredictability does not render individual lives or organisation performance meaningless. Consequences of actions are inherently unpredictable over the long term, but in the short term established rules and conventions located within an organisation culture, together with the desire of almost all individuals for a predictable and pleasant life, leads to stable patterns of behaviour. Similarly, in the short term, the implementation of policies will proceed as planned but will then routinely diverge from the plan. Some key individuals may lose touch with ideas while others misinterpret instructions, or perhaps other organisations withhold information or fail to deliver resources on time. As Mintzberg[14] points out in his writing on organisation strategy, the realised strategy (the one that actually happens in the world) is not the same as the deliberate strategy (the one intended).

The implications of this line of thinking for current government funding of university research are significant. As previously argued, the pattern of government funding and oversight assumes a linear, cause and effect relationship between government funding and the production of ideas and innovation. Considered from a complex-systems point of view this policy is doomed. Complex systems are inherently unpredictable and the research system, made up of many organisations and individuals, is no more predictable than any other. Inputs of money may or may not lead to research outputs, indeed it is unlikely that money will be used on the precise projects indicated in funding applications because ideas and staff change quickly and rivalry between and within research organisations may lead to quick changes in research design and/or aims. Good research is rarely, if ever, predictable and cannot guarantee outputs. Indeed, the more ambitious the aim, the less likely short-term results become.

The message for funding bodies becomes even more bleak after further consideration of the implications of the complex patterns of cultures in the research community. According to Schein[15] organisation culture is 'a pattern of shared basic assumptions', while Limerick and Cunnington define it as 'the set of beliefs assumptions and values

shared by a majority of those within the organisation'.[16] Schein[17] further locates organisation culture in a three layer hierarchy:

- artefacts
- espoused values
- basic underlying assumptions

Artefacts are 'visible organisation structures and processes' such as architecture, dress and technology. Espoused values include strategies, goals and philosophies. Basic underlying assumptions, assumptions that guide individual behaviour, are taken for granted. Each layer is successively less visible than that above it, with deeper layers hardest to change.

Culture is passed on to new members of an organisation over time, not only in the learning of values and procedures and in formal induction programs but also by more subtle revelations yielded as people become recognised members of the organisation. Newly hired workers observe artefacts such as architecture, technology and style of clothing. They are told about the 'espoused values' of the organisation, they gradually become aware of the basic assumptions that guide behaviour, and their world view gradually alters to become consistent with them. Such notions are both implicit and powerful, the deep layer of culture that forms the core of organisation self. This will normally be related to a broader culture (for example, a disciplinary culture and natural culture) but will have a particular 'twist' relevant to the organisation in question. Thus organisation members share ideas about such things as rewards and punishments, about teamwork, about quality of work, and about power and influence that are broadly consistent with a wider culture. Despite this particular organisation, cultures may differ markedly in detail. For example, one research organisation may be status-conscious and reward individuals, another may be basically egalitarian and reward teams, but both will be consistent with ideas about rewards for effort, high quality of work and commitment to research.

In any national research system there will be many different and often competing research cultures. A varied research community includes many universities and research bodies and many disciplines. All academic research bodies, however, are arguably similar in that they have, as part of their basic values, shared underlying assumptions about knowledge, research and intellectual freedom. All also share an understanding that research is time consuming and results unpredictable.

In contrast, the culture in government bureaucracies in charge of oversight of research outputs and research funding is, we suggest, uniformly modernist at this basic level. Control is the key aim of policy, boundaries within and between organisations are viewed as strong, and measurement of outputs is the major bureaucratic task. From the government perspective, 'research management' really means the effective management of human and financial resources. The Australian Department of Employment, Education, Training and Youth Affairs (DEETYA) system strives for a stable system that uses simple quantitative tools to measure progress. This is, of course, legitimated by a government who is often called into account by a broad constituency who believe control over expenditure should be both tight and obvious.

This contrast between government bureaucratic culture and academic research culture inevitably exacerbates tensions between funding bodies and researchers. Neither really understands the perspective or language of the other, nor is ever likely to be able to do so. A routine response of bureaucracy in this situation is to strive for further control, further measurement of inputs and outputs, if only because the research process in the middle is a 'black box', fundamentally unknowable. The modernist mind-set is

peculiarly inappropriate to research management because it is focused on order, simplicity of purpose, measurement, short term and steady results, and control.

Is there a better model? Writers on innovation in the management literature provide some indication. Inkpen and Choudhury[18] suggest that, in the face of uncertainty, an absence of deliberate strategy can stimulate creativity and promote innovation. Allied to that they suggest the need for flexibility in organisation structure. Quinn and Voyer[19] support this comment on structure. Stacey[20] suggests that the job of the leader in a turbulent world is not to direct others but to establish conditions where creativity is released—loose boundaries, freedom to select activities, follow up ideas. Brown and Eisenhardt[21] concur, emphasising the need for good communication links and extensive interaction.

The overall message is to create communication rich organisations with flexible structures within which empowered individuals can pursue their ideas. There is an acceptance of turbulence rather than an attempt to damp it down, and a move away from measurement towards encouragement. In this style of organisation resources would not, as is now the case in Australia, be spent on assessment of applications and outputs but on communications, infrastructure and the research itself. It is, from this perspective, far more efficient and effective to provide seed funding for all research ideas that show a hint of promise and then follow up any research programs that can demonstrate progress with significant funding at a later stage. Assessment at this later stage could be inexpensive—no results, no funding. Such a system would build the research capacity of the Australian community, encourage new researchers and encourage a diversity of ideas. Priorities would emerge, they would not be artificially (and inefficiently) enforced.

In contrast, the basis of a bureaucratic approach to research management is measurement of inputs and outputs. In the next section of the argument we explore the defects of this practice.

The Flaws of a Quantitative Approach to Research Management

Applied to government research funding the notion of a quantitative approach is, at best, problematic. The basic task of developing a set of valid measures for success in funding is complex. To a certain extent inputs can be measured in dollar terms—though putting monetary values on the cultural and intellectual resources fundamental to good research is difficult. Research outputs are far harder to measure. Even more difficult to quantify are the relationships between research and the broad innovation and productivity aims of research policy. In response to such challenges DEETYA has emphasised those aspects of science policy that can be measured using their current level of human resources based knowledge and skills. The result is a concentration on financial inputs and very simple counting of units of outputs.

For bureaucrats (anxious to progress in their careers and charged with the role of measuring progress) the specialised knowledge and research skills required to make judgements on the quality of research that covers the entire range of scientific disciplines, methods and agendas are at best secondary concerns. A recent example of the consequent difficulties (and the lack of research background of DEETYA staff), publicised by the Australian Broadcasting Commission's 'Science Show' radio programme, is the refusal by DEETYA to accept a 'Letter to Nature' as a refereed publication for the purposes of an annual publication survey on the grounds that a letter to a journal did not qualify as a substantial research article. Those who are familiar with scientific journals will know that journal articles in *Nature* are called letters for historical reasons and that a publication in *Nature* is usually a highlight in a good research career.

In Australia, at the present time, the method of measuring research performance for the purpose of resource allocation is the Research Quantum Publication Count (RQPC). The RQPC is an exhaustive effort to collect and classify publication outputs by DEETYA. Essentially, it is confined to annually counting the gross number of entries each institution can place in the simple classification categories which are differently weighted for funding purposes.[22] At the 'top end' these include refereed journal articles, research books and chapters in books. Further towards the 'bottom' come refereed conference papers, unrefereed conference papers and creative works. The RQPC has received considerable criticism after a KPMG Peat Marwick audit in 1994 revealed that the error rates of publication classification for the RQPC ranged from 32 to 80%, with an average of 60%. An acceptable rate of error is considered to be 10% or less.[23]

Aside from the inaccuracy of the publication classification system, most criticism of the RQPC mechanism of rewarding research performance is made on the basis that it has no way of measuring quality.[24] No subtlety is evident in this process, it is a simple counting of publications. A very good journal article in a highly prestigious journal rates the same as one in a new and perhaps temporary journal, a groundbreaking book or idea is the same as a routine 'me too' book. Academic writers are therefore edged towards the writing of routine material because careers will not prosper without publication and it is much harder to write genuinely new material than follow established paths. The old maxim 'publish or perish' prevails.

This quantitative government approach comes within the paradigm of modernist management, which asserts that if a property cannot be measured it must be treated as subjective conjecture.[25] This outlook is summarised in Kelvin's Dictum that 'when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind'. The application of modernist theory to intangibles such as knowledge and information is a particularly vexing problem and is a matter of great concern within the economics[26] and management[27] disciplines. For example, a prominent economic theorist, Joseph Stiglitz, has dismissed the suggestion that:

> we can write down a production function for knowledge, with inputs producing outputs, and having done that, we can then treat the production of knowledge just like that of any other good.[28]

Carter, in an essay for a 1995 OECD forum on the knowledge-based economy shared this sentiment.

> My colleagues in sociology and history love to tease economists by calling economics 'Queen of the Social Sciences'. This royal status is based largely on measurement; our ability to quantify our variables ... Traditional systems of accounts, on which both our micro and macroeconomic analysis rests, give a distorted picture of the rising knowledge-based economy. Is our crown at risk? Dare we admit that we can't really quantify at all? That the emperor's, or, worse yet, the empress's, clothes don't fit? That she may be naked?[29]

Management theorists appear to be facing similar difficulties. For example, a recent introduction to a special forum on innovation in the *Academy of Management Review* has suggested that

> The organisational innovation research ... has focussed on the variables that facilitate squeezing the most out of organisations ... The work has searched for statistically significant associations among innovation and specialisation, functional differentiation, professionalism, participatory work environments, administrative

> intensity, and slack resources, to name a few of the most common variables. All of these searches have concentrated on the means to effectively squeeze innovative activity out of organisations, with little regard for the continuous accumulation of knowledge that provides the source of that capability'.[30]

So, the process of knowledge creation represents a problem for management and economics as well as for government research policy, but why have these difficulties arisen? The answer to this question arguably lies in the incompatibility between a sophisticated concept of knowledge and the 'river bed' assumptions underpinning the mainstream of conventional management and economics, and subsequently imported into government processes. The norms of this mainstream include an emphasis on rationality,[31] quantitative measurement[32] and an assumption that 'data represent the truth about an objectively measured world'.[33] By contrast, the growing trend in knowledge theory is to consider that there is a subjective and tacit dimension to knowledge which cannot be articulated or quantified.[34] Polanyi's notion of tacit knowledge has fuelled intense debate on the need to treat knowledge differently from other commodities.[35] Furthermore, there is a steadily growing body of theory which suggests that tacit knowledge is an essential part of the innovation process.[36] From this point of view the ponderous and numbers-driven approach of government research bureaucracies is particularly flawed because it cannot, under any conceivable circumstances, take tacit knowledge into account.

Fiol's review of current innovation management theory provides a further line of argument. She advocates the metaphor of organisations as knowledge sponges in which the quantity of innovative output is dependent upon how much knowledge the organisation has absorbed to begin with. In other words, we cannot learn without a good knowledge base.[37] The type of pre-existing knowledge also dictates what sort of knowledge can be absorbed, assimilated and exploited by the organisation.[38] For the research community generally this view reinforces the need for the broadest possible base of knowledge in order that new ideas cannot only be initiated but also understood and further developed. Innovation without prior knowledge is improbable from Fiol's point of view because it requires a 'repackaging' of ideas into socially useful goods or processes, something which cannot take place without a good knowledge base. In terms of university research and universities the pursuit of efficiency in terms of generating tangible outputs such as publications (i.e. squeezing the sponge) for the minimum degree of input fails to direct enough attention to building of the knowledge base. It can be argued that it actually erodes the tacit knowledge base of the research effort and results in a diminished innovation capacity. An example of this point, which demonstrates the importance of tacit knowledge and intangible organisational capital, is the debate on the decline in the visibility of Australian science at an international level.[39] One process which 'fills the sponge' is the diffusion of knowledge through communication networks.[40] The erosion of these networks was dismissed by Bourke and Butler as a source of the decline in the visibility of Australian science on the grounds that the proportion of co-authorship with international researchers had actually increased. However this may not represent the full story. Although these formal alliances and networks are readily measurable through analysis of collaborative grant applications and citation analysis, current research has emphasised the importance of informal networks in the diffusion of information.[41] Again, these informal networks, which have been suggested to be major conduits for tacit knowledge, are very difficult to quantify and are unlikely to be adequately assessed using quantitative measurements such as citation analysis and publication counts.[42] The deterioration of this 'organisational capital', represented by

these networks, has been suggested as contributing to the decline in the visibility of Australian science at the international level.[43] Most importantly, the present RQPC system used by DEETYA does nothing to rectify this problem. The types of output which may represent the building of these networks, such as conference papers and working papers, are discouraged in favour of refereed journal publications.

Conclusion

Fuller[44] remains optimistic about the management of science for national competitive advantage, while Porter[45] gives it a central role in explaining the competitive advantage of nations. Like any activity, scientific research can be enhanced by the effective combination of labour and capital.[46] However, we suggest that capital needs to be considered in broader terms. Tacit knowledge and the networks which carry tacit knowledge are a vital part of organisational capital even though they are not readily measurable or easily managed.

It is commonplace to suggest that more money needs to be given to research, and as the argument has already suggested, links between research and industry and research clusters (the CRCs) further encouraged. On the other hand, the tendency towards ever more (pseudo) precise measurement of outputs must be reversed. This will take time because it is embedded in carefully constructed bureaucratic careers as well as a still dominant modernist mind-set. Although management and accountability are inevitable, the trend towards measurement over research needs to be reversed. The bureaucratic/linear system of research policy making and implementation is deeply entrenched but can be slowly altered with positive actions such as those that have been proposed. Given the cultural inertia of the bureaucratic culture this process of change can be likened to turning around a super-tanker—it can be done but takes time and the pilots (and in this case these are pilots who admit they cannot assert effective control) must be willing to wait for a considerable period of time before the results of policy change are evident.

Perhaps most importantly we should bear in mind Fiol's metaphor of organisations as sponges. Rationalist management of university and basic research places a premium on product outputs and efficiency. In other terms, squeezing the sponge. The warning that 'A sponge that has been left to dry out to the point where it can no longer absorb anything new will not generate outputs no matter how effectively one squeezes it'[47] is timely for the management of Australian public research.

Notes and References

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