RESEARCH MANAGEMENT AND COMMERCIAL MARKETS: CULTURAL CHANGE IN AUSTRALIAN RESEARCH INSTITUTIONS

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Research institutions and universities have undergone significant organisational change during the past decade. While these organisations have been pressed to attract an increasingly larger proportion of their research budget from industry, they have introduced business principles and practices in order to manage their scientific research and to focus it more on producing commercial outcomes. As individual scientists and institutions have responded to these changing research environments, the research cultures of these organisations have undergone a transformation. This paper seeks to unpack the notion and process of 'cultural change' and to emphasise the social dynamics that underpin such change.

Keywords: CSIRO, organisational change, cultural change, research management

RESEARCH ENVIRONMENTS AND CULTURAL CHANGE

Researchers in Australia have been confronted during the past two decades with rapidly changing research environments.[1] There has been an increased emphasis in government policy on making scientific research more relevant to national and community needs, on directing funding towards specific targets and on increasing funding from business enterprises to support public sector research. Funding has become more competitive and there has been a growing emphasis on accountability, both in terms of deciding where to allocate resources and in judging how effectively those resources have been used. Increasingly, research outcomes are expected to be demonstrably of social or economic advantage to the nation, and, in particular, to the organisations within which the research takes place.

As the broad research environment has become more complex and uncertain, institutions have at the same time been compelled to deal with the changes more independently and more actively.[2] Both public research institutes and universities have responded to their changing economic, industrial and political environments by moving toward a more commercial style of organising, planning and carrying out their scientific research.

Changing environments, however, are a major source of uncertainty for organisations. They raise uncertainties for management trying to maintain control in relationships with external organisations and they also raise uncertainties for management trying to maintain control across boundaries within their own organisa-

tion. In order to reduce the level of organisational uncertainty, managements often forge new links or alliances with groups that were previously considered outsiders. This process of social exchange involves action between individuals within organisations, action between individuals across organisations, and institutional action between organisations.[3] The organisational changes that have resulted from these exchanges have often been described in terms of 'cultural change' suggesting changes in deeply embedded organisational values.

The concepts of 'organisational culture' and 'cultural change' have often been used as general labels to capture all that is different or unique about an organisation. Used in such a general way, these concepts tend to mask the deeper social dynamics of organisations and the social action and interaction that underpin change. It is one thing to identify changing values and perspectives within an organisation, but it is quite a different thing to explain the process through which such change has occurred. By simply describing change or difference as cultural, the day-to-day imperatives and social dynamics that drive change and support the 'difference' between institutions fall from view and are instead reflected as mere shadows in the distance. An alternative approach is to focus on the intersection between changing research environments and individual and collective adaptation to these environments. From this perspective, it is possible to maintain an emphasis on the social dynamics of cultural change, rather than simply identifying the change.

In this article, we explore the process of cultural change within Australian research institutions as they and their research practitioners negotiate changing research environments. In particular, we focus on the penetration of commercial objectives and business practices into the core activities of research scientists and research managers. From our analysis, we argue that research managers must recognise that with the increasing mix of activities and objectives within large research institutions the critical management task is not simply to manage the change from one cultural perspective to another. Rather, the key task will be to manage the alliances between quite different cultural perspectives.

Our analysis draws principally on fieldwork carried out during 1993 in the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO). The CSIRO is Australia's largest employer of professional scientists and one of the world's largest multidisciplinary research institutions. The study, carried out in collaboration with the CSIRO, explored the nature and depth of cultural change within four divisions of the organisation. Fieldwork was carried out in two phases. In the first phase, in-depth interviews were carried out with 144 research scientists and managers in four divisions of the organisation. The divisions were selected from three of the six CSIRO institutes, each with a different focus scientifically and industrially, and each with a different history of association and relationship with its respective industries or stakeholders (as they are described by CSIRO). Respondents included a mix of scientists in terms of designations and salary levels, time spent in the organisation, age and sex (where possible), and representation of the different programs and projects within divisions. There was some variation between the divisions, but each sample was relatively representative of the composition of the divisions.

In the second phase, the preliminary findings from the first phase were presented to staff groups in each division after which a follow-up survey was distributed to the original interviewees, as well as to a wider group of respondents. The follow-up survey yielded a total of 155 responses. In total, data were collected from interviews with 201 respondents including both research scientists and research managers.

The extent and pace with which the CSIRO has responded to changing economic and political imperatives, particularly in the last six to seven years, has been dramatic and the changes have reached to the heart of the Organisation's structures. Although the CSIRO and Australian universities have their own particular experiences, similar changes have been taking place in research institutions throughout the world.[4] The experiences within the CSIRO can therefore provide important insights into the way the organisation of research is changing more generally.

THE CHANGING RESEARCH ENVIRONMENT

Financial Competition

The national environment within which publicly funded research is carried out in Australia has become increasingly competitive. However, it is not that less research funding is available, but rather that competition for funds takes place across research organisational boundaries. The extent to which this change has occurred in Australia is evident in national data on research expenditure.

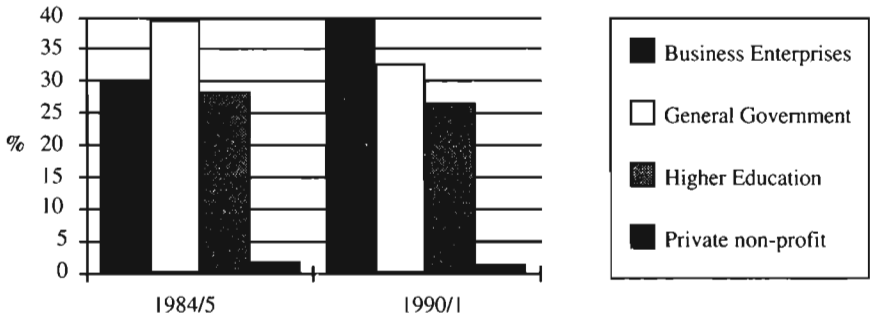
Total gross expenditure on research and experimental development in Australia has more than doubled between 1984/5 and 1990/1, from A$2.4 billion to over A$5 billion in 1990/1.[5] In constant 1984/5 prices, this represents a growth of 45.5 per cent. This growth in research expenditure, however, has been unevenly distributed across the business, government and higher education sectors and has been matched by a considerable growth in the overall size of the system.[6] Gross expenditure on research in Australian universities, for example, has doubled and business expenditure has nearly trebled, while expenditure by Commonwealth research institutes has been far more modest. Between 1984/5 and 1990/1, university research spending increased by 97 per cent at current prices (from A$686 million to A$1,351). Expenditure in the Commonwealth government research sector increased by 55 per cent ($669 to $370 million), while in the private sector, business expenditure has increased by 177 per cent (from $653.7 to $1,813.2 million). This represents a significant proportional shift of Australian research expenditure away from public sector research institutions towards private sector research, and, to a lesser extent, toward higher education research (see Figure 1).[7]

One outcome of the 1980s has been that while research activity in the university system has expanded by 6200 person years (36 per cent) between 1984/5 and 1990/1, the level of activity in the Commonwealth research sector, according to the same indicator, has remained virtually unchanged (11,119 to 11,386 person years).[8] The CSIRO, for example, actually declined in overall staff numbers during the 1980s, with 1993 being the first year to show an increase on the 1981 staff level of 7,381 (7406 in 1993). The Defence Science and Technology Organisation (DSTO), Australia's second largest research institution, has recently announced its expectation

of reducing its overall staff by 15 per cent during the next four years. In late 1993, the Minister for Science began actively seeking ways to 'rationalise' the activities of the Australian Institute of Marine Science (AIMS), the Australian Nuclear Science and Technology Organisation (ANSTO) and the CSIRO through divisional amalgamations.

FIGURE 1

Gross Expenditure on Research and Development by Sector: 1984/5 and 1990/91



Source: Australian Bureau of Statistics, Catalogue 8112.0, Table 1.

Pressures on Organisational Boundaries

One of the organisational responses to this more competitive funding market has been that research institutions and universities in Australia have developed closer funding links with industrial enterprises. Commonwealth research institutes such as CSIRO, DSTO, ANSTO and AIMS now seek to attract at least 30 per cent of their research expenditure from non-government sources and have introduced procedures for identifying and supporting 'priority' areas of research. Industry-based research funding collected through industry levies is now also allocated more competitively through corporations and councils, and distributed to encourage industry research organisations to be more active in the commercialisation of research. Government research institutes and universities bid competitively for these industrial funds.

While the system has become more competitive and thrown organisations such as the CSIRO and universities into competition with each other for research funds, new groupings and alliances have been formed that challenge traditional organisational boundaries. There has been a trend in the university system toward the formation of research centres and multidisciplinary research. Government funding programs have promoted collaborative research through the formation of Key Centres for Teaching and Research and Collaborative Research Centres (CRCs). Infrastructure funding mechanisms have promoted the sharing of major facilities and

specific project collaboration has been promoted through the provision of collaborative university and industry research grants. Between 1981 and 1991, business sector funding for research in higher education increased by 74 per cent, indicating a considerable growth in industry and university research linkages.[9] Research intensive business enterprises, public research institutes and universities have increasingly sought new models for collaborative research arrangements.[10] The agreement reached between the Commonwealth government and the CSIRO to adopt a 30 per cent external funding target was introduced as a means of increasing collaboration with industry and other research agencies. Similarly, the DSTO has recently announced in its corporate plan for 1993-97 that its in-house expertise will be augmented by a program of contracts, agreements and cooperative research ventures at both the national and international level.[11]

With research environments becoming both more competitive and more commercially oriented, the boundaries of research activity have come under considerable pressure to adjust. New alliances between research groups and business partners have emerged and old alliances have taken on new meaning as research managers have been given responsibility to manage the boundaries between science, industry and commercial activities.

Organisational Responses to Changing Research Environments

In the CSIRO, there is now a marked difference in the relationship between scientists and managers that existed in the 1960s and that which predominates in the 1990s. Three decades ago, the issue of who drives the research agenda in institutions such as the CSIRO was described in quite unambiguous terms. These priority decisions were generally derived through negotiation between the Chief of the division and the researchers within the division.

> No matter what the field, the purpose, or the source of the financial support, the research staff decide, devise and direct their own research programs, and every research officer in the C.S.I.R.O. is expected within a few years of the commencement of his research career to take full responsibility for his own area of research activity.[12]

During the 1960s, the relationship between the Chiefs of divisions, research scientists and the organisation executive was described as the core building block for research activity. Gillespie, for example, has noted that in the CSIRO of the 1960s, the process of decision-making always moved in two directions between the three categories of researcher, Divisional Chief and the executive:

> Individually or collectively it is required of members of the research staff that they are able to understand and place in proper perspective the problems of the community with which they are particularly concerned, and exercise skill and judgement in the choice of direction in which to conduct their investigations ... It is their responsibility to make the best use of the costly facilities under their control.[13]

The role of the corporate body was seen as ensuring that the scientist did not experience undue frustration through unsympathetic administration: 'Flexibility of organization is essential and it must be adaptable to the individual, not the individual to it'.[14] This observation contrasts starkly with more recent views that emphasise the importance of shifting this responsibility into an organisational struc-

ture where 'business-like practices ... ensure that its resources are used with maximum effect'.[15] The CSIRO Chief Executive, for example, has argued that the boundary between business and public sector research should be almost indistinguishable: 'Bureaucrats and scientists acting alone are not usually the best judges of what scientific breakthroughs will be ... a seamless link with the business community is required'.[16] There is evidence that suggests the seam between industry and research is not a hierarchically managed inter-connection between organisations, but rather, a laterally connected set of relationships between individuals and organisations.[17] Yet organisational structures often reflect quite different assumptions.

Through the 1980s, the CSIRO was confronted with changes both in government and public expectations, as well as changes in financial and industrial commitments. Through a decade of economic rationalist policies and economic downturn, the Organisation has been particularly vulnerable to severe questioning of its value to the nation.[18] It has been subject to growing pressure to not only demonstrate its worth, but to adopt 'business-like practices' to ensure that its resources are used with maximum effect.[19] Some of the major organisational changes adopted during the past decade are worth summarising.

In 1984, the CSIRO established a commercial arm (SIROTECH Ltd.) to manage its business activities and promote the transfer of research output with commercial potential into the industrial sector. In 1987, the Organisation went through a process of restructure that reduced the number of divisions by 25 per cent. In 1989, a target was adopted for external earnings at a proportion of 30 per cent of total income and, in 1990, a priority setting exercise was set in place across the entire organisation to bring national economic and commercial factors into the priority setting process. At the same time, employment categories across the entire system were reclassified into a set of functional areas, and a single eleven-level structure covering all staff, including the Chief Executive, was introduced. The structure and operation of the salary system, together with new competency-based guidelines, were made a central part of the CSIRO's human resource strategy.[20]

In 1988, the CSIRO Executive Committee took the decision to make research projects the basic unit of research for planning, funding and managing purposes. Thus, the project and program managers assumed increased importance within the organisation, taking responsibilities for managing staff and resources, as well as becoming more accountable for securing income. As a senior executive has put it recently, 'the pursuit of funds for research has become a new and crucial responsibility'.[21] This responsibility has been driven home further at the program manager level. The latest policy circular on the definition of tasks for program managers includes the following tasks: identifying commercial prospects; managing intellectual property; implementing the Organisation's commercial policies; evaluating the capability of program resources to contribute to commercial outcome; working with the commercial manager; and proposing pricing and intellectual property outcomes. During the 1990s, the CSIRO has become more strategic in terms of human resource management and more commercial in general, seeking new ways to facilitate greater staff mobility, collaborating more extensively with

academic and industry researchers and exploiting this linkage by the use of multi-disciplinary teams with higher levels of internal and external interaction.[22] Further, the changing environment has led to the acceptance of a need for 'more focused training and development', a 'realignment of the entire business strategy' and the 'development of a whole new set of skills and behaviours that were quite foreign to many scientists'.[23] These changes reflect organisational pressures on researchers and research managers to become engaged across a whole range of commercially related activities. At the same time, however, our data show that from the perspectives of practising scientists these intentions sit ambiguously alongside deeply held views about scientific excellence and industrial relevance.

NEW BOUNDARIES AND NEW TENSIONS

There is now a stark difference in the nature of organisational tensions that predominated during the 1970 and 1980s, and that which has emerged during the 1990s. Flood has noted that the 1970s and 1980s produced organisational tensions as the autonomy of scientists and the scientific values by which their work was judged became increasingly reorganised through strategic planning based on corporate expectations of relevance and accountability. Although he argues that CSIRO links with industry have been remarkably unproblematic in the way they have struck a balance between the internal demands of the organisation for scientific excellence and the external demands for relevance, he observes that the strategic management of the Organisation in setting corporate objectives has threatened this balance between industry and science. He described the CSIRO of the 1980s as an organisation that has changed from an institutional style that supports autonomy to a strategic style with centralised direction, less individual freedom, bureaucracy and accountability requirements.[24]

In the wider research environment of the 1990s, different patterns of communication, new criteria for assessing performance and success and new patterns of individual and organisational allegiance are becoming embedded in the research management activities of the CSIRO. For example, the introduction of an organisational wide personnel evaluation system, the Personnel Performance Evaluation (PPE), represents a powerful symbol of corporate management over what was previously experienced as a science or peer driven system of personnel evaluation. Yet only 21 per cent of respondents to the present study responded negatively toward the introduction of the system, and of this 21 per cent, many acknowledged that the mechanism was useful for the Organisation in the 1990s.

A view widely shared among the 200 respondents interviewed during the present study was that the research environments of the 1990s were substantially different from the environments of 1980s and that the organisation and its research scientists needed to adjust to these changes. Ideas about the importance of industrial relevance and multidisciplinary team-based research appeared deeply embedded in the broad expectations and organisational values articulated by researchers across the four divisions. These embedded values stood in contrast to a markedly weak acceptance of commercial values (in terms of research being driven by financial considerations) and the introduction of new organisational structures for managing

research. Expectations and ideas about the need to concentrate CSIRO research in areas of greatest value to Australian industry and benefit to Australia's social and economic development were strongly linked to long-standing values about scientific excellence and performance. Although there were differences in ideas about how such links should be steered, the importance of the link was unambiguous. This positive view of industrial relevance was also reflected in the level of importance respondents placed on the industrial and scientific networks within which they carry out their work.

The two most welcome changes identified in the study were:

- 'increased relevance of research to industry'; and,
- 'more multidisciplinary/team based research'.

In contrast, the least welcome changes were overwhelmingly identified as:

- 'an increased emphasis on generating income'; and,
- 'an organisational emphasis on what was identified as 'line management structures'.

Although the research cultures of the divisions studied clearly reflected the articulated corporate goals, broad tensions and ambiguities could be observed in perceptions about the way the integration of science and industry was managed. These tensions were not so much associated with a 're-direction' of scientific research, a sharper focus on industrial application, or an increased emphasis on strategic planning, but rather, were associated with the commercial strategies that were perceived to be driving them. It was not so much the introduction of performance management processes that struck chords of cultural discontent among respondents, but the view that they were driven by economic criteria *perceived* to be incongruent with ideas about scientific excellence or industrial relevance. The tension in the 1990s is therefore not so much between researchers as 'autonomous scientists' and organisational demands for corporate objectives and judgements of outcomes. It is more between the scientific and socio-economic values that provide the cultural capital for 'relevant research' and the commercial values that provide the economic capital for the institutions themselves.

This tension was clearly evident in a follow-up survey carried out during the second stage of the present project. In this survey, a series of question items were drawn from the earlier interviews to elaborate clusters of research 'values' associated with scientific, industrial, management and commercial activities. Responses to nineteen items were scored and sorted according to their level of support. A factor analysis of the nineteen variables supported the earlier findings of the study that both scientific excellence and industrial relevance were two separate but complementary sets of research values. On the other hand, the two items associated with judging research according to 'commercial value' scored lowest on the mean scale and were experienced as intervening in this complementarity.[25] These responses serve to illustrate the inclusive nature of the boundary between scientific research and industrial application and the exclusiveness of boundaries between these domains of activity.

The organisational changes experienced within the CSIRO are mirrored in the Australian higher education sector. In 1987, a Commonwealth Government White Paper on higher education reform ushered in a new era in higher education research. The reforms that followed removed the college and university binary divide and created a Unified National System of higher education. This brought previous teaching-only institutions into the university research marketplace, as well as new disciplines such as podiatry, nursing, occupational therapy and home economics. As the research environment moved from one largely characterised by individual autonomy and local institutional decisions about priorities to one characterised by centralised policy and competitive institutional processes, new amalgams of institutions were steered toward developing research management plans and concentrating research effort into new organisational groupings such as research 'centres', research 'programs' and research 'institutes' that characteristically intersect traditional departmental research boundaries.[26] Universities throughout the 1980s established commercial arms to market their teaching and research activities, set up offices of research to manage research within institutions, introduced research priorities and established rules for setting up, managing and disbanding research centres.[27] The identification of performance indicators to measure research output is a feature of current research management concerns, and issues of quality, national relevance and industry links are high on university policy agendas.

Tensions and struggles at the boundaries of organisations can be seen in many parts of the research system. In the 1992 Australian budget, the Government announced a commitment to establish an Australian Technology Group (ATG). This decision had its roots in a range of policy proposals intended to improve the capacity of the Australian research system to derive commercial benefit from research. It is interesting to compare the negative response to the proposal from universities and from university commercial arms with the positive response from the Federated Australian University Staff Association (FAUSA). Inherent in the ATG proposal was the recognition that new structural forms of research are emerging and that they require some nurturing and support. Inherent in the initial university response was the recognition that the ATG threatened the organisational boundaries that institutions were actively shoring up to maintain control of potential commercial advantage. Inherent in the FAUSA response was the recognition that the ATG might have the potential to soften the tightening corporate boundaries being developed by the universities.

In the higher education sector, a concentration of research efforts into new institutional structures has led to the creation of over 800 research centres. The majority of these centres do not rely on university funding for their research activity, but draw on the host organisation's institutional umbrella for basic infrastructure support and scientific status. Their structure, although governed by university rules, is not driven by traditional university departments, but by a combination of interests that include those inherent in scientific disciplines, industry expectations, academic institutional aspirations and commercial opportunities.[28] The underlying range of imperatives that support this type of structure reflects the multi-faceted nature of universities in the 1990s and to some extent explains why it is that the sweeping

changes to the university system in Australia have met with so little collective opposition.[29]

The fifty CRCs established recently in Australia have adopted a variety of different management forms. A recent study of the management styles and systems for decision making among these centres found that they have generally responded to their research environments by adopting management strategies 'contingent upon their own situations'.[30] The authors describe the emerging organisational structures from these forms of collaboration as 'influential enclaves of collaborating research practitioners'. However, the centres are already creating new boundaries of allegiance and in some cases corporate structures have emerged to create new identities and new allegiances. A critical issue for the centres is the extent to which they will remain linked to the science or industrial systems from which they grew.

One of the increasingly difficult challenges for universities has been to strike a balance between maintaining the freedom among their academic staff to engage in their preferred research activities and the fulfilling of their institutional obligations to the state to which they belong. Institutional attempts to maintain this balance have been made all the more difficult during the 1980s as universities have travelled further down the pathway to the market to sell the knowledge they have produced.[31] This international 'crisis', as it has been called, is in part a boundary struggle between different domains of research activity. On the one hand, researchers are pressed by government and institutional policy to produce and transfer knowledge (science activities) toward clearly defined socio-economic objectives (application). On the other hand, they are encouraged, through various policy mechanisms, to be concerned with securing and maintaining market niches for selling that knowledge (commercialisation).

A recent study of university and industry research links in Australia noted that the range and types of links within the system are extremely varied. In some cases, the links were driven predominantly by industry; in others, they were driven more by researchers in the university system; and, in many, by a combination of both. But in all cases, the importance of individual contacts was paramount.[32] At the same time these activities are increasingly managed through hierarchical systems that claim to both protect the interests of the scientist and maintain control of the market activities (corporation). These four domains of research work, 'research', 'application', 'commercialisation' and 'management', are dominated by different sets of reward criteria, different sets of objectives, different ways of measuring success, different modes of communication, and different forms of symbolic capital, supported by different forms of legitimating authority. These four domains, shown in Chart 1, represent conceptual distinctions rather than mutually exclusive fields of activity. In practice, most researchers are, to varying degrees, working in more than one domain. The point, however, is that social boundaries between each domain are constantly being negotiated by a range of actors, including scientists, institutions, managers and politicians. The cultural perspective of research institutions reflects the outcomes of the boundary struggle between these domains.

Boundary struggles between these domains, although often manifest in different forms, are evident in both higher education and public research institution. For

example, scientists involved in our CSIRO study identified 'increased relevance to industry' as the 'most welcome change' in their organisation. On the other hand, the largest category of responses concerning the 'least welcome change' was the increased emphasis given to generating income. This apparent contradiction can be explained by recognising that industrial relevance has been a deep-seated cultural value embedded in the organisation for many years (a soft boundary between research and application).[33] On the other hand, the increasing imperative on scientists to be responsible for generating their own research funds is a new organisational response to increasingly limited public funds. It was this demand to bring in income, rather than notions about relevance, that the scientists described as new and foreign to their way of doing research (a hard boundary between commercialisation and research). In particular, it was the introduction of line management systems to 'manage' this process that struck the deepest chords of opposition (a soft boundary between commercialisation and management). Most respondents, when asked about what they would most like to change in their research environment, referred to reducing line management and increasing horizontal, rather than vertical, communication and accountability. In short, they articulated a desire to get closer to the industrial action interface, rather than be embedded in a hierarchical structure. The recent decision by the CSIRO Executive to disband SIROTECH, the organisation's formally centralised commercial arm, and transfer the commercialisation responsibilities to the divisions is consistent with the scientists' preference to be close to the 'action'. The ambiguity, however, is that it also brings 'closer to home' the commercial imperatives of the market-place.

CHART 1

Domains of Research Work and Associated Cultural Components

Cultural Components	**Domains of Research Work**			
	Research	Application	Commercialisation	Management
Predominant Discourse	Science	Industrial	Market	Organisational
Major Actors	Scientists	Industrialists	Business Managers	Administrators
Predominant Symbolic Values	Excellence	Relevance	Money	Ownership
Predominant Authority	Peers *(Is it good science?)*	Government/ Public Opinion/Peers *(Does it work?)*	Market forces *(Is there profit?)*	Executive *(Do we benefit?)*

BEATING THE BOUNDARIES

The data collected during the CSIRO study and from a recent study on industry/university research links show that collaboration between research in universities, public research institutes and industrial enterprises are predominantly developed and maintained at the personal, rather than institutional, level. With academic institutions, this is largely because there is no single point in the innovation process where formal structures, such as commercial arms or research offices, can best tap the needs of industry. On the other hand, individual academics are able to fulfil independent roles in various innovation complexes. It would seem that formal structures can provide support for these networks, to the extent that they manage institutional agreements that flow as a consequence of research links. The point here is that practical advances toward increased industrial relevance are made by scientists themselves and through these emerging links they are extending the boundaries of research beyond traditional departmental structures. However, the management systems that have been introduced to manage the changing environment are often in conflict with these shifting boundaries.[34] It is therefore the modes of control (both at the institutional level and at the level of central government) that have been imposed on researchers, rather than conflicting ideas about research direction, that lie at the heart of these tensions. This is not to make a judgement of the 'value' or 'appropriateness' of introducing business principles in these hard times, but simply to point out that the tension is largely between generating and performing 'relevant' research and managed commercial processes, rather than between the different demands, expectations or rewards inherent in the academic and industrial sectors.

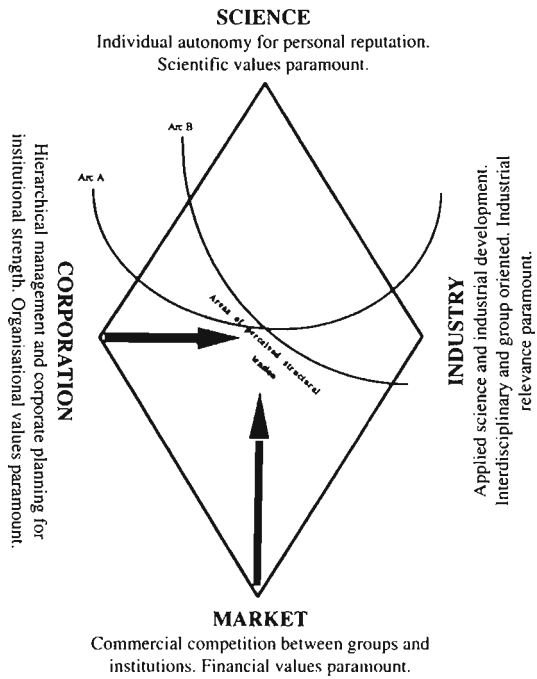
In the CSIRO, strategies, structures and planning frameworks are helping to drive the formation of a new corporate identity, however, this was not perceived commonly at all levels in the organisation. In our study, we found perceptions that some of the current ethos, systems, processes and structures limit or inhibit the move towards the realisation of corporate objectives and that there was uncertainty and lack of consistency across the organisation regarding the expected roles, responsibilities and functions of line management. This is perhaps, among other things, because management principles and practices are confronting a range of scientists' views of how the science and industry interface seam should be sewn. As one respondent during our interviews put it: '[We] asked for leadership but what we got was line-management'.

At the same time, universities are increasingly seeking to control and manage research activities within their own institutional boundaries. In Australia, this has given rise to varying forms of commercial 'companies' that are owned by, or part of, individual universities. These enterprises intervene directly between academic researchers and the commercial world toward which much of the university research effort is directed. In a recent publication, aptly named *This Gown for Hire*, the author describes how Australian Vice-Chancellors have grappled with the problem of integrating industrial firms with general campus activities and, in the process, given birth to a new profession of managers whose task is to 'motivate, keep motivated, and extract performance from the academic staff'.[35] Reflected here is a boundary struggle between the extended research networks of the academic and

the commercial networks of the institution; at stake is the control of the research funds, the research directions, and, ultimately, the economic and social return from the research product.

Figure 2 presents a schematic view of this tension in the current Australian research system. The arc labelled 'A' represents the tension described in the literature prior to the 1990s as arising from a struggle between the autonomous scientist and scientific accountability, and the corporate demand for relevance and organisational accountability. In essence, this was a struggle between the work domains of research and management over the control of the boundaries of industrial relevance. The arc labelled 'B' represents the struggle between an integrated approach to scientific excellence and industrial relevance that is *perceived* as being at odds with commercial or business-oriented measures of accountability. Here the struggle is between the integrated domains of research and application, and the management domain over the boundaries of commercial activity. It is not that researchers necessarily resent this move toward commercial operations. In fact, in the CSIRO study described above, respondents often welcomed what they saw as an increased range of research opportunities. Rather, their concern was more with what they described as the commercial values that were *driving* their system (excellence and relevance) rather than being an integrated part of it.

FIGURE 2
Pressure Points of Cultural Change



These contradictions are not surprising, particularly as research organisations have been moving through a period of major change. The implications for management are that during change and organisational uncertainty it will be critical to understand the social dynamics inherent in the process of cultural change. These social dynamics are best explored not through studying different organisational models or identities, but through studying the inter- and intra-institutional interplay of action. This calls for a focus on the nature of cultural boundaries, rather than on what is 'bounded'.[36] In the research environments of the 1990s, it will be important for research managers to recognise that with the increasing mix of activities in research institutions, the management task is not simply to steer a cultural trajectory from one perspective to another. Rather, the key task will be to manage the integration of quite different cultural perspectives toward the broader corporate objectives. To achieve this integration it will be necessary to recognise the struggle between the competing demands in different research domains, such as those identified in Figure 2.

In a recent American study, Sackmann identified functional domains in the work place as formative in the construction of cultural sub-groups because of the different meanings that were attributed to external events. She found that similarities in cultural knowledge were larger between similar functional domains across divisions than between different functional domains within divisions.[37] In the same way, newly emerging forms of innovation in the Australian research environment may not be bounded in the way that universities or research institutes seek to bind them. The formation of CRCs and other new structural forms may well be the Australian harbingers of organisations that are neither university nor research institute, and neither entirely public nor private. These new organisational forms reflect a shift toward organised research that is, in effect, disorganising traditional research organisations.

Whatever the form of research organisation that emerges, it is likely that the most enduring ones will be those that have successfully integrated the demands, rewards and organising principles of the different sectors from which they have emerged. It is this integration that provides the real challenge for the organisation's management, but it is also a challenge for science itself. As Arie Rip has pointed out recently:

> It may well be that democratic and administrative values cannot be taken up in science without modification; but neither can scientific values (whatever these are) remain unassailable.[38]

The present research system is certainly more competitive and less restrained by organisational boundaries than it was a decade ago. Research communication and research collaboration are taking place in different organisational contexts and new forms of organised research are emerging that are directly confronting disciplinary, sectoral and corporate research boundaries. At the same time research organisations are seeking to redefine and sharpen their corporate identities. While research institutions such as the CSIRO were described in the 1980s as being characterised by the introduction of the organising principles of business management, the 1990s are emerging as a period of reorganisation, characterised by the integration of commercial imperatives with long standing expectations about scientific excellence and industrial relevance.

NOTES AND REFERENCES

1 An important review of the CSIRO in 1976 reported that the organisation was operating in a substantially changed environment, but Johnston and Buckley, writing in retrospect, have noted that the authors of the report may not have appreciated the full extent of the changes nor the growing public dissatisfaction with the organisation's view of the place of science. See R. Johnston and K. Buckley, 'The shaping of contemporary scientific institutions' in R.W. Horne (ed.), *Australian Science in the Making*, Cambridge University Press, Sydney, 1988.

2 Maassen and van Buchem make this same point in their discussion of the situation in the Netherlands. They point out that international trends have meant that higher education institutions in many countries have been pressured toward institutional autonomy but at the same time accept a greater degree of institutional vulnerability. P.A.M. Maassen and M.T.E. van Buchem, 'Turning problems into opportunities: The University of Twente' in F.A. Schmidtlein and T.H. Milton (eds), *Adapting Strategic Planning to Campus Realities*, Jossey-Bass Inc, San Francisco, 1990.

3 Sociologists such as Simmell and Homans have emphasised the cost/benefit relationship in human interaction, that is, that in human exchange, various choices are more or less rewarding or costly, between at least two persons. From this perspective, analyses focus on the boundaries of exchange, but tend to avoid the question of the extent to which there is a cultural bias to the selection of choices and the extent to which such bias has a root in social structure. However, decisions to choose from a range of alternative courses of action are made because some meaning or value is attributed by the chooser to potential outcomes and these meanings are a driving force in such choices. See M. Douglas, *How Institutions Think*, Routledge & Kegan Paul, London, 1987.

4 See, for example, E.J. Tuininga, 'Research management in professional organisations: searching for new impulses', *R&D Management*, 20, 2, 1990, pp. 139-153; A. Rip, T. Misa and J. Schot (eds), *Managing Technology in Society: The Approach of Constructive Technology Assessment*, Cambridge University Press, 1994 (forthcoming); and J. Ziman, 'Academic science as a system of markets', *Higher Education Quarterly*, 45, 1, 1991, pp. 41-61.

5 Australian Bureau of Statistics, *Research and Experimental Development, All-sector Summary, Australia, Catalogue 8112.0*, Table 1, 1993.

6 The rationalisation of the Australian higher education system from 1987 has involved the amalgamation of 24 universities and 47 Colleges of Advanced Education and Institutes of Technology to form 38 universities in a Unified National System. This substantially increased the number of academic researchers and institutions eligible for Commonwealth government research funds.

7 Some of this growth in the business sector may be due to more accurate procedures of accounting for research expenditure introduced by businesses to gain maximum advantage from the government's 150 per cent tax concession scheme introduced in 1984.

8 Australian Bureau of Statistics, *op. cit.*; Department of Employment, Education and Training, *Selected Higher Education Statistics 1991*, Australian Government Publishing Service, Canberra, 1991.

9 National Board of Employment, Education and Training, *Crossing Innovation Boundaries: The formation and maintenance of research links between industry and universities in Australia, Commissioned Report No 26*, A Report of the Board prepared by the Centre for Research Policy and Sultech, Australian Government Publishing Service, Canberra, 1993.

10 *ibid.*

11 See Department of Defence, *Corporate Plan, 1993/97*, Department of Defence, Canberra, 1993.

12 D.T.G. Gillespie, 'Research management in the Commonwealth Scientific and Industrial Research Organization, Australia', *Public Administration*, Spring, 1964, p. 23. (Most of the literature of this period refers to the researcher exclusively in the masculine form.)

13 *ibid.*, p. 22.

14 *ibid.*, p. 23.

15 CSIRO, *Report of the Institute Model Study*, Canberra, August, 1987, p. 3.

16 J. Stocker, 'Australia's economy - A stool missing a leg?', Speech to the National Press Club, Canberra, March 11, 1992.

17 See National Board of Employment, Education and Training, *op. cit.*

18 The earlier history of reviews of the organisation and structural changes from the late 1970s through the 1980s are described by J. Landsberg, 'The management of scientific research', *Prometheus*, 7, 1, June, 1989.

19 CSIRO, *Report of the Institute Model Study, op. cit.*, p. 2.

20 CSIRO, *Human Resources Plan*, Canberra, 1991.

21 A. Blewitt, 'Corporatisation and change - the reality of commercialisation for HR management in CSIRO', Paper prepared for the IIR Conference, Human Resource Management, Reposition and Realign your HR function for Greater Organisational Effectiveness, April, 1992. p. 8.

22 *ibid.*

23 *ibid.*, p. 7.

24 J. Flood, 'The advent of strategic management in CSIRO: A history of change', *Prometheus*, 2, 1, 1984.

25 Centre for Research Policy, *Research Cultures and Organisational Change: Case Studies within the CSIRO*, Draft Report, Centre for Research Policy, University of Wollongong, April, 1994.

26 S. Hill and T. Turpin, 'The clashing of academic symbols', *Science As Culture*, 20 (forthcoming); S. Hill and T. Turpin, 'The formation of research centres in the Australian university system', *Science and Technology Policy*, 6, 5, 1993, pp. 7-13.

27 In a recent survey of universities, the Centre for Research Policy found that most universities had recently established rules for establishing, managing, and, if necessary, disbanding research centres. One of the key features of the rules was the managing of multidisciplinary research and the relationship between centres and departmental structures.

28 S. Hill and T. Turpin, *Science and Technology Policy , op. cit.*

29 See S. Aungles, Paper presented to the Fifth APROS Colloquium, East West Center, Honolulu, Hawaii, December 12-15, 1993.

30 S. Liyanage and H. Mitchell, 'Organizational management in Australian Cooperative Research Centres', *Technology Analysis & Strategic Management*, 5, 1, 1993, pp. 3-14.

31 For this perspective of the situation, see B. Neville, 'The charm of Hermes: Hillman, Lyotard, and the postmodern condition', *Journal of Analytical Psychology*, 37, 1992, pp. 337-353. These tensions also raise the question about the extent to which the marketed knowledge is also shaped by market demands.

32 See National Board of Employment, Education and Training, *op cit.*

33 See D.T.G. Gillespie, *op. cit.*; and J. Flood, *op. cit.*

34 Wasser, in an analysis of the European situation, has described this shift in activity as creating an identity crisis among universities throughout the world where '... the qualitative change is so radical that the very identity of the university and the justification for even using the term itself may be called into question'. See H. Wasser, 'Changes in the European university: From traditional to entrepreneurial', *Higher Education Quarterly*, 44, 1990, pp. 111-122. Keat, writing on the British academic reaction to the 'enterprise culture', has noted that academics now complain that their research 'is now being judged by intellectually facile considerations of "marketability"'. See R. Keat, 'Consumer sovereignty and the integrity of practices', in R. Keat and N. Abercrombie (eds), *Enterprise Culture*, Routledge, London, 1991.

35 P. Wing, *This Gown for Hire: A History of the Australian Tertiary Institutions Commercial Companies Association*, Anutech, Canberra, 1993.

36 In an interesting way, Barley has studied the culture of the funeral industry and analysed different domains of action. The definition of domain is a symbolic category where members share at least one feature of meaning. His argument is that, in different domains, quite mundane and every day paraphernalia are open for interpretation as 'lit candles hovering above both the icing and cake of culture'. Our point is that domains of action are as important as the cultures themselves, for it is within these domains that the meanings themselves are formed and communicated. See S.R. Barley, 'Semiotics and the study of occupational and organisational culture', in P.J. Frost, L.F. Moore, M. Reis Louis, C.C. Lundberg, and J. Martin (eds), *Reframing Organizational Culture*, Sage Publications, London, 1991.

37 This approach focuses analytical attention on the boundaries of cultural groups and investigates organisational culture, not so much as sub-cultures or monolithic cultures, but as layers of organisational culture that are formed by, and, in turn, *inform* actors as they variously engage in activities *across* the cultural layers. See S. Sackmann, *Cultural Knowledge in Organisations*, Sage, London, 1991, p. 165.

38 A. Rip, T. Misa and J. Schot (eds.), *op cit.*, p. 12.