OCCASIONAL PAPERS

Rigour and relevance

Extending the role of the social sciences and humanities in public policy research

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Executive summary

Australia needs to encourage a new form of research that contributes directly to the formulation of policy in government. Such research is initiated by the end user rather than the researcher. It is characterised by being strategically driven, problem oriented and cross-disciplinary.

It is becoming increasingly necessary to draw on knowledge from many disciplines in meeting the challenges and opportunities of the modern economy and society. Scientific or technological research, in particular, benefits from the inclusion of complementary work in the social sciences and humanities. We need to think about ways the practice of *interdisciplinary* research can be encouraged and facilitated.

Interdisciplinary research is likely to be driven by end-user requirements. The creation of new knowledge to address those requirements rarely falls within the ambit of a single discipline: new knowledge for policy application in such areas as the natural environment, health and society, energy, transport, communication or innovation is inherently interdisciplinary.

Interdisciplinary research presents a major challenge for researchers and research organisations. It requires disciplinary knowledge, built up through a rigorous commitment to research excellence, as well as a sound understanding of the way knowledge will be applied, gained through exposure to practice. Interdisciplinary research needs to be both excellent in its content and relevant to end-user needs and expectations.

Interdisciplinary research also requires supportive infrastructure and management of a type not easily accommodated in university settings. This paper looks the sort of arrangements that can accommodate the demands for rigour (excellence) *and* relevance (application and use) in research performance. It points to the need for effective collaborative arrangements within research organisations, as well as between research organisations and government end users.

The need for interdisciplinary approaches is becoming more pressing, as policymakers look for evidence as a basis for new program interventions and to make sure that scarce resources are directed towards resolving real, identified problems and delivering intended outcomes. In the area of climate change, water policy and the natural environment generally, policymakers and their advisers are calling for evidence drawn from research as a basis for policy and program design.

As the Australian Government moves to a new focus on innovation, the time is opportune to address ways in which government can support and fund problem-oriented, interdisciplinary research. The government has already signalled its determination to improve collaboration within the research community and between the public and private sectors, and has announced its intention of reviewing the system for allocating research funds.

The increasingly strategic approach to Australian public policy in the security, economic, social, cultural and environmental domains implies a need for research that contributes directly to policy formulation and implementation in those areas.

Policy research tends to be initiated by the end user (typically, government departments), rather than by the researcher. It is characterised by being strategically driven, problem-oriented and cross-disciplinary. As such, it necessarily based on what Ernest Boyer referred to as the 'scholarship of integration'. It differs from the other forms of scholarship (discovery, application and teaching), which have a strong disciplinary orientation.

Breakthroughs in research and development tend to occur at the intersection of disciplines and where there is an identified problem to be solved or an opportunity to address an unmet end-user want. Many discoveries lie dormant until an application is found, quite often in an area unforeseen or unimagined by the researcher or inventor. This is not an argument against 'basic' research: such breakthroughs rely on a solid foundation of curiosity-driven basic research that has as its purpose the extension of the frontiers of knowledge in a particular discipline.

Disciplinary research is rigorous, involving an ongoing quest for fundamental understanding and pushing the boundaries of knowledge. However, it is often of little direct relevance to policy issues and problems. Relevance requires both the rigour of disciplinary research *and* the insights that come from multiple perspectives on economic, social and environmental issues derived from a range of disciplines — within and between the physical, natural and life sciences, the socio-economic sciences and the humanities (Metcalf et al 2006).

Discussion and debate about research policy in recent years has had a very strong *industry policy* flavour, with a particular focus on industrial innovation. There has been very little discussion of research policy in the broader *public policy* domain and the contribution that research can make to improved policy outcomes and impacts. In the light of the current water crisis, for example, it is clear that water research has been substantially underfunded over the past 10 years.

From another perspective, there has been a tendency to regard research undertaken in or for the public sector as 'public good' or 'public benefit' research, implying a commitment to curiosity, discovery and research excellence and limited concern with application and adoption. That view is not sound, as public good research has both basic and applied dimensions. That is, public benefit research can be both excellent and relevant to policy formulation (as evidence), and can find its way into implementation through policy and program applications.

In general terms, however, applicable, policy-relevant, problem-oriented and strategically driven research (whether undertaken in universities, in other public research organisations or within the government sector) is not well funded — particularly when it crosses disciplinary boundaries. Capacity for policy research within government was substantially curtailed from 1996, with the abolition of a number of research bureaus and specialist policy research divisions. Public programs have since been implemented without the benefit of knowledge generated through research, with the result that resources have been wasted or results have failed to meet expectations.

More recently, government ministers, policymakers and departments have been saying that they want to *take action* on evidence. They want to explore opportunities and resolve problems on the basis of breakthroughs in science, technology and design, and they want to draw on the knowledge created through research in the humanities, arts and social sciences to understand the economic, social, environmental and cultural impacts of actions (or inaction), and of the process of adoption and implementation. Only through this broad-based approach is it possible and feasible to develop options and actions that address national problems and produce national benefits.

The solution proposed in this paper is a greater commitment to interdisciplinary research that works at the boundaries of disciplines through *a scholarship of integration*. Such an approach seeks to integrate research into a larger body of concepts and ideas, to interpret and draw it together in a way that addresses problems — and opportunities. The scholarship of integration is the ability to synthesise knowledge from disparate disciplines to resolve pressing problems. Policy issues in the natural environment, health and society, energy, transport, communication, emerging industries and innovation are likely to respond best to this approach.

This paper proposes a series of changes to enable integrative research in the public policy arena:

- establish a research plan in each government portfolio to address critical policy problems and issues, funded as a required element of overall portfolio budgets
- reorient of the Cooperative Research Centres Program to enable CRCs to address fundamental questions that affect public policy and industry performance
- extend the rural research and development corporation model to other industry sectors
- reconfigure the research and teaching agenda in universities, so that administrative units, reward structures and funding systems encourage rather than inhibit interdisciplinary work.

Integrative research will not replace discovery research, but complement it. By encouraging the research community to apply its skills to pressing problems facing Australia in the most direct and immediate way, it will open a new career path for researchers and maximise the return on Australia's investment in research.

Chapter 1

Introduction and issues

This paper focuses on the conduct of interdisciplinary research in contemporary public policy contexts. It looks at:

- issues to consider in relation to interdisciplinary research between the humanities, arts and social sciences (HASS) and the science, technology, engineering and medicine (STEM) sectors in the public policy domain
- institutional factors that promote or hinder commitment to interdisciplinary research
- funding and financing
- options for expanding interdisciplinary research in public policy domains.

1.1 Demand factors

In the current public policy environment, decision makers want to resolve problems *and take action* on the basis of knowledge and evidence drawn from research. Moreover, not only do they want to explore opportunities and resolve problems on the basis of breakthroughs in science and technology, they also want to understand economic, social, environmental and cultural impacts and what needs to be done to enable the application of those breakthroughs.

While new policy responses to major economic, societal and environmental problems and strategies built on innovation call for ideas and creative solutions, the testing and validation of ideas and actions calls for knowledge based on evidence generated through research and scientific inquiry. Modern public policy demands that research reflect the input of many disciplines.

As governments demand evidence to support new policies and program interventions (or justify existing ones) in social, economic, environmental and cultural domains, so they will demand evidence drawn from research across disciplines in the social sciences, the humanities and the natural sciences.

Evidence for practice invariably calls for research findings from a range of disciplines and *integrates* those findings to inform judgment and guide implementation. Rarely does one disciplinary standpoint represent and capture all the perspectives that are necessary to drive public policy formulation, implementation and review.

In particular, understanding the social impacts of policy decisions calls for contributions to the research endeavour from the social sciences and the humanities. Current concerns about global warming and climate change have drawn attention to the importance of evidence-based research drawn from those disciplines, which are taking an important place in policymaking for natural resource management, biodiversity and sustainability. Their contribution is recognised in publicly funded research agencies, such as the Bureau of Rural Sciences and the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

CSIRO Resource Futures

The Resource Futures program is focused on improving Australian communities' prosperity and quality of life. The program achieves this by:

- providing rural and urban communities with strategies, tools and principles to help plan and invest in their future so as to maintain and sustain ecosystems, biodiversity and long-term growth
- influencing policy and decision makers on natural resource management using CSIRO's research and development work, including the modelling and testing of possible scenarios
- integrating the contributions and needs of the community, the economy and the environment using a 'systems approach' to tackle the difficult question of how to best manage development and resource use in Australia now and into the future.

Source: CSIRO

Humanities research can help governments improve policy and bring about social, economic, political and cultural change. It can provide policymakers with a means to assess the social, economic and ethical impact of their ideas and take account of increased public concern about the consequences of scientific and technological advances. Such research can help governments make the most appropriate technological choices.

1.2 Overseas developments

Since 1994, the European Union (EU) has directly funded research in the social sciences and humanities addressing major EU societal challenges. The Fourth Framework Program (FP4), which ran from 1994 to 1998, introduced socioeconomic research for the first time. Through its Targeted Socio-economic Research Program, it provided a budget of €112 million for 162 projects working in three main areas—science and technology policy options; education and training; and social exclusion.

The EU has enhanced the role of what it refers to as the 'socio-economic sciences and humanities' in its 7th Framework Program, to run from 2007 to 2013. For the first time in the history of the framework programs, an entire theme (Theme 8) specifically addresses the sector. Theme 8 is directly linked to the Lisbon Agenda, through which the EU seeks to address what it sees as Europe's current and future challenges: growth, employment and competitiveness; social cohesion and sustainability; quality of life; and global interdependence.

Theme 8 is designed to provide 'a new knowledge base for policies in these and related fields: that is, a European policy-relevant knowledge base informed by the humanities' (EC 2007a). Research carried out under Theme 8 is intended to be collaborative, across countries and across disciplines. The humanities are expected to offer contributions that address values and developments in society and, towards that end, engage in problem-oriented research clusters.

FP7—Socio-economic Sciences and the Humanities
Budget: €610 million (2007–2013)

During FP7, EU research in Socio-economic Sciences and the Humanities promises to study and offer answers to questions regarding the demographic change and quality of life; education and employment in view of the current economic trends; global interdependence and the transfer of knowledge; the well-being of democracies and political participation; cultural diversity and values.

The link between research and policy is safeguarded by ensuring that the issues examined are of high priority at the European level and are addressed by community policies. In fact, research at the EU level has particular advantages; it can develop European-wide data which are needed to heighten our awareness of complex issues.

The research questions to be addressed within the timeframe of the FP7 will be drawn from the following areas:

- Growth, employment and competitiveness in a knowledge society (innovation, competitiveness and labour market policies; education and life-long learning; and economic structures and productivity)
- A combination of economic, social and environmental objectives in a European perspective (socio-economic models within Europe and across the world; economic and social and cohesion across regions; the social and economic dimensions of environmental policy)
- Major trends in society and their implications (demographic change, reconciling family and work; health and quality of life; youth policies; social exclusion and discrimination)
- Europe in the world (trade, migration, poverty, crime, conflict and resolution)
- The citizen in the European Union (political participation, citizenship and rights, democracy and accountability, the media, cultural diversity and heritage, religions, attitudes and values)
- Socio-economic and scientific indicators (the use and value of indicators in policymaking at macro and micro levels)
- Foresight activities (the future implications of global knowledge, migration, ageing, risk and the emerging domains in research and science).

Source: EC (2007b)

With the growing significance of industry and public policy issues that require interdisciplinary responses and solutions, it is important to look at the way policy research strategies are devised and funded, across government, across portfolios and between government and industry. In Australia, this imperative is occurring as economic conditions call for very tight expenditure restraint.

1.3 Approaches to interdisciplinary research

Interdisciplinary research tends to be problem-oriented and quite often user-initiated, or end-user focused, compared to the curiosity-driven orientation of researcher-initiated scholarly inquiry. It builds 'theories' that seek to identify and explain the causes of problems and suggest actions and results that will be achieved through particular interventions. Experiments and pilot studies are also becoming more important in policy decision-making and program design.

Interdisciplinary research requires an ability to synthesise knowledge from disparate disciplines to resolve problems. This involves using 'multiple working hypotheses', as distinct from the 'single working hypothesis', or linear model.

In the linear model, which is the most commonly employed scientific and research method, researchers test the validity of a single explanatory concept through investigation, trial and error, and experiment.

Linear models involve functional and discipline specialisation, and work against integrative thinking because they undermine our ability to keep in mind the whole while working on individual parts. They encourage sequential or parallel resolution of discrete parts of a policy problem, with the result that what is optimal from the perspective of one discipline will take precedence over what is optimal from the overall public policy perspective.

Explanations of phenomena often involve the elucidation and coordination of several influences that contribute to a combined result. Such complex explanations are made easier by the use of multiple working hypotheses. Instead of a simple succession of thoughts in linear order, integrative thinking is complex and involves looking at phenomena from different standpoints.

Complexity need not be overwhelming. Understanding complexity means looking for patterns, connections and causal relationships. Interactions and collaborations help.

Successful interdisciplinary researchers have found ways to integrate and synthesise disciplinary depth with breadth of interests, visions and skills. Students, especially undergraduates, are strongly attracted to interdisciplinary courses, especially those of societal relevance.

1.4 Implications for public policy

Public policy has suffered from interventions based on reactions to the symptoms of problems rather than to their causes, or narrow views about what constitutes a problem that needs to be addressed. Clarification of objectives and planned outcomes (what it is that a policy intends to *achieve*) often comes later, during implementation or even during policy reviews. Attempts by Auditors-General to define policy and program objectives have at times attracted the criticism that those attempts are an involvement in policy matters.

Some observers are critical of the military intervention in Indigenous communities in the Northern Territory in late 2007, on the grounds that it was a symptomatic response. In their view, it reflected a political need for government to be seen to be doing something—anything—and government's predilection to address problems by injecting funding before it had considered all policy options and strategies. Most Australian Government programs have started out as 'funding programs', rather than as strategic responses to well-articulated problems or perceived opportunities.

With governments taking a more strategic approach to policy, there is a call for a greater commitment to interdisciplinary research agendas. This will, in turn, raise questions about interdisciplinary research capacity and the resources available for that research.

Chapter 2

Capacity and capability

This section surveys Australia's capacity for interdisciplinary research, and examines some major impediments.

Almost 15 years ago, the Australian Science and Technology Council (ASTEC) reported:
The humanities and social sciences have a powerful influence in shaping the way we see our society and evaluate changes and developments in it. By permeating our understanding of issues, and shaping them through use of language and critical analysis, the humanities and social sciences achieve broad changes to people's views of the world. They have a strong ethical component which, when fused with analytical techniques, gives them great strength in tackling complex social questions.

In recent years, efforts to harness Australia's knowledge base to economic development have concentrated on science and technology. In ASTEC's view, more effective use could be made of the investment in these areas if the human, social and economic factors were better understood and this understanding integrated with scientific and technological advances. (ASTEC 1993).

ASTEC pointed to a major gap that appeared to lie between researchers in the humanities and social sciences on the one hand, and potential beneficiaries of their research (including the natural sciences and technology) on the other. The council identified the major causes of the gap as:

- inadequate communication between practitioners and researchers across disciplines, and with the general public
- institutional impediments to transdisciplinary research
- the lack of an identified responsibility within government for broad policymaking on research in the social sciences and the humanities
- ineffective use of humanities and social sciences research in policymaking.

ASTEC held that the Australian institutional framework supporting the development and application of knowledge did not encourage the necessary interaction between the social sciences, the humanities, the natural sciences and technology. It identified three groups who could help to bring about the necessary changes:

- those in government who plan for and fund research
- research workers
- users of research results.

In ASTEC's view, scientific and technical specialists needed to acquire a broad understanding of the context within which their research was to be applied and the communications skills to identify and respond to the needs of possible users or beneficiaries of their research.

Specialists in all disciplines (including the social sciences and humanities) needed to disseminate the essence of their research in a form that could be understood by non-experts. Finally, all educated Australians should acquire the ability to comprehend broad advances in knowledge in the social sciences, the humanities, science and technology.

In the years since ASTEC's report, there has been uneven progress towards these targets. In 2006, the Council for the Humanities, Arts and Social Sciences (CHASS) published a report (Metcalfe et al 2006), again calling for a higher level of cooperation and collaboration in research between the humanities, arts and social science sector and the science, technology, engineering and medicine sector.

2.1 Academic career motivations

Academic institutions still recruit faculty largely on the basis of their depth of knowledge and expertise in single disciplines, not on the basis of their competency across several disciplines and their ability to engage with disciplinary experts through teams and collaborations. In many institutions, there is suspicion and resentment if a specialist in one area shows interest in another specialist area.

Notwithstanding the efforts to promote interdisciplinary research over the past 15–20 years, establishing a commitment within universities and research organisations has been fraught with difficulties that require attention, consideration and action by universities, industry and policymakers:

Interdisciplinary research (IDR) can be one of the most productive and inspiring of human pursuits—one that provides a format for conversations and connections that lead to new knowledge. As a mode of discovery and education, it has delivered much already and promises more—a sustainable environment, healthier and more prosperous lives, new discoveries and technologies to inspire young minds, and a deeper understanding of our place in space and time.

Despite the apparent benefits of IDR, researchers interested in pursuing it often face daunting obstacles and disincentives. Some of them take the form of personal communication or 'culture' barriers; others are related to the tradition in academic institutions of organizing research and teaching activities by discipline-based departments—a tradition that is commonly mirrored in funding organizations, professional societies, and journals. (National Academies Press 2004)

Researchers who are motivated to undertake interdisciplinary research are impeded by the academic reward and promotion system and department-based budgeting systems. However, interdisciplinary research plays an essential and increasing role in permitting researchers to go beyond the limits of their own disciplines to investigate questions of ever-increasing complexity and social urgency.

Another impediment is that researchers tend to be promoted on the basis of their publication record, preferably in prestigious international journals (which are usually organised around a single discipline approach), and their capacity for winning grants from the Australian Research Council (ARC) or the National Health and Medical Research Council (NHMRC). Much less weight, if any, is given to their work on commissions and contracts for problem- or issue-oriented research defined by end users and performed as a specialist consultant.

The ARC's Linkage program and research centres programs aim to link researchers with end users, and to build those links into the programs. The Linkage program has been particularly attractive to public and non-government sector end users.

2.2 Organisational infrastructure

Interdisciplinary research requires supporting organisational infrastructure that is not easily accommodated in university settings.

Interdisciplinary research centres are difficult to establish and sustain as workable academic units within a typical university environment. Many centres are created as 'virtual' organisations, with a defined mission and research strategy and with 'members' drawn from disciplinary departments. A virtual centre may have many members, but very few staff. These centres do not attract most career-committed researchers, and offer few of the opportunities required for a viable organisation.

Centres for research and teaching have been established with a strong interdisciplinary focus to address problems and issues with a strong end-user orientation. The cooperative research centre (CRC) model is probably the best known example.

Research and teaching centres established with a strong funding base, sourced from government and/or industry to meet a clearly identified research need, with provision for permanent staff appointments and opportunities for career development, are in a good position to develop an interdisciplinary orientation.

Research centres often operate at some distance from decision-making frameworks. It is desirable for researchers to be close to decision makers and, where appropriate, involved in decision making.

2.3 Research management practices

In industry, government research organisations and other non-academic settings, research management emphasises teams, collaboration and problem-driven approaches. Leaders with clear vision and effective communication and team-building skills can catalyse the integration of disciplines (see box).

From time to time, researchers have endeavoured to establish interdisciplinary research networks. Their success has depended on institutional commitment, as well as on research and organisational leadership.

Pests and Diseases Image Library (PaDIL)

The Pests and Diseases Image Library (PaDIL) has been developed and built by Museum Victoria's Online Publishing Team, with support from Plant Health Australia. Project partners also include the Western Australian Department of Agriculture and Food and the Queensland University of Technology.

Additional image providers included Dr Laurence Mound (ANIC, CSIRO); Dr Roger Shivas (Queensland Department of Primary Industries and Fisheries); and Dr Mallik Malipatil (Agriculture Victoria, Department of Primary Industries).

PaDIL combines leading-edge technology in light microscopy, digital imaging and image manipulation. Utilising an innovative, non-molecular mechanism, it provides 'virtual specimens' of a type only previously possible using low-power scanning electron microscopy. The result is:

- A series of images is captured, each providing an in-focus image of part of the photographed organism.
- Each series of images is then combined to create a single new image, built from only the in-focus pixels from each individual image.
- Specimens are shown in true-life colour.
- Destructive preparation of specimens is not required.
- Diagnostic images show the user the best orientation to view the specimen.
- Results allow a user with a microscope to focus on different parts of the viewed organism, simultaneously comparing what they see against a single PaDIL image.
- Operating costs after equipment purchase are negligible.
- All images are copyright free for non-commercial purposes.

These virtual collections of high-quality digital images, illustrated diagnostic keys and online tutorials overcome the expense of maintaining centralised technical reference collections. Illustrations are focused on key diagnostic features, and diagnostic material is available to a much larger group of users.

Taxonomic expertise is unnecessary, particularly where diagnosis is aimed at a limited group of target species (i.e. pest species on a quarantine target list). Taxonomists and scientists involved with plant health are driving species selection (targeted species lists) and character image capture selection (through interpretation of higher rank and specific keys).

PaDIL can be accessed at http://www.padil.gov.au/aboutOverview.aspx.

2.4 The academic division of labour

A further problem working against interdisciplinary research is the organising principle of universities, which is based on academic disciplines. Organisations built on disciplines foster excellence in teaching and research, but do little to address end-user needs and requirements in industry and government.

Both in universities and in private-sector professional services firms, working across disciplinary boundaries presents major challenges. Co-location is often seen as an answer, but even when people are co-located they tend to 'home' to their disciplinary 'nests' unless managers can deliver strong leadership and ensure rewards for collaboration. Interdisciplinary collaboration is as much social as it is structural.

Strategies and structures for working across organisations have been the subject of a very extensive literature. 'Matrix' forms of organisation have been tried and generally fail. Professional services firms look to 'project' forms of organisation to address each project, with performance being assessed by line managers and project team managers.

2.5 Government relationships with universities

In Australia, it is almost a mantra that businesses find it difficult to work with universities in partnerships and collaborations. Government departments and agencies voice similar concerns. The evidence indicates otherwise (Howard Partners 2007abc), but more can be done to build effective relationships and interactions between the two sectors — particularly in relation to strategically driven, problem-oriented research.

Apart from funding arrangements, very little is understood about how governments interact and develop relationships with universities for policy advice and interaction. Governments are often participants in CRCs and at times contribute core funding for research and teaching centres in specific policy areas. There is an expectation that research outputs will be useful for policy.

More often, relationships with universities are through contract research and consultancy arrangements. The value of research contracts and consultancies with universities has risen substantially over recent years. Many are in the form of collaborations, joint ventures and partnerships. However, government procurement guidelines make the development of longer term partnerships and collaborations difficult. Such arrangements rarely provide for building capacity and 'preparedness' for policy contingencies.

Few universities are going to take a risk and establish a capability for policy research with an unknown and incalculable level of demand. One reflection of this problem is the lack of research capability to deliver relevant and applicable results for innovation policy. The current Review of the National Innovation System has little to draw in the area of innovation policy research that is relevant and applicable to Australia. There is a strong reliance on research undertaken in Europe — evidenced by the appointment of advisers from European universities to the review.

Government departments and agencies have worked with universities on ARC Linkage grant arrangements, but the success rate is low. ARC Linkage grants are not always an efficient or an effective way to resource policy-relevant research. Researcher objectives and priorities are not necessarily oriented towards preparing material for input into the processes of policy formulation, implementation and review.

There are fundamental differences in cultures, attitudes, behaviours and expectations between policy advisers, program managers and academically oriented researchers. Relationships are strengthened through 'employer engagement' strategies and a growing understanding on the part of all parties about where and how they can benefit and contribute.

Resolving institutional constraints that reduce the capacity for interdisciplinary research may require the introduction of new incentive and rewards systems within universities and a greater acceptance of the contribution that can be made by the university sector in the area of applied research and consulting.

Promoting interdisciplinary research agendas and integrated research products may also require experiments with new academic structures.

Chapter 3

Current arrangements for interdisciplinary research

This section identifies and reviews current arrangements for the delivery of integrated, interdisciplinary research.

3.1 University research centres

Universities are among many 'providers' in the commissioned and contract research market. They compete with publicly funded research agencies and commercial providers for the research work.

Growing interest in problem-oriented and interdisciplinary research within the higher education sector has led to the formation of university research centres that can accommodate both researcher-driven and user-driven agendas. The capacity to attract both discovery- and government-oriented and industry-funded research depends on being able to present a genuinely interdisciplinary focus and respond to the policy and business contexts in which research is funded.

University research centres can be grouped according to their funding sources: the ARC, the university, governments and industry.

3.1.1 ARC-funded research centres

The ARC funds research centres that support large teams to undertake focused and sustained investigations into challenging and important problems. The funding enables groups of first-class researchers to come together to work on a problem and to leverage additional research funding from other sources.

ARC 'centres of excellence' are prestigious hubs of expertise through which high-quality researchers maintain and develop Australia's international standing in national priority research areas. Through ARC Centres of Excellence, a high level of collaboration occurs between universities and other organisations in Australia and overseas.

The ARC also co-funds three centres of excellence with universities and government:

- the Australian Centre for Plant Functional Genomics (with the Grains Research and Development Corporation)
- the Australian Stem Cell Centre (with the Department of Innovation, Industry, Science and Research)
- National ICT Australia, also called NICTA (with the Department of Broadband, Communications and the Digital Economy).

The ARC also funds 'special research centres', which play an important role in nurturing young researchers by providing a high-quality, supportive research environment for postgraduate research education and postdoctoral training. Special research centres also provide a link to international centres and programs, higher education institutions, government, industry and the private sector generally.

3.1.2 University-funded research centres

Universities have adopted a practice of supporting 'designated research centres' where it can be demonstrated that the university has, or has the potential to have, research strengths based on a capability and reputation for research excellence. Universities provide infrastructure and salary support for designated research centres based on an expectation that the centres will attract competitive research funding and industry funding to become financially self-supporting.

The centres are intended to generate 'critical mass' in research domains and provide a focus for the research interests of members of faculty. Most centres have few full-time researchers — centre staff have responsibilities and accountabilities in their disciplinary areas.

Research centres may have full-time directors, business managers and administrative staff who spend time on managing research programs, submitting grants applications, developing and maintaining relationships with sponsors and contributors in government and industry, and preparing and publishing reports and papers. Those activities are essential for building profile and underwriting the financial viability and sustainability of a research centre. Activities are funded from subscriptions and from income derived from user-initiated research contracts and consultancies.

Research contracts and consultancies delivered through university research centres provide opportunities to combine the delivery of relevant and useful outcomes with academic rigour. They can also provide an assurance of independence and objectivity. Research centres in professionally oriented disciplines, such as engineering, economics or finance, for example, can be quite successful in generating income from consulting.

The performance criteria of university research centres most often relate to their capacity to generate income from competitive grants. Researchers expect that their industry-oriented work will also contribute to building their academic careers through publication and helping to leverage competitive research grants. At the same time, however, government and industry sponsors expect their funding to deliver research results that are useful, relevant and practical.

Those dual expectations inevitably lead to tension between researchers and their industry or government sponsors. The tension is exacerbated when there is insufficient funding from competitive research grants to provide for capability building and management infrastructure, and consulting is seen as income that merely underwrites the management infrastructure of a centre or subsidises partially funded academic work. In such circumstances, industry and government prefer to deal with private sector consulting firms.

In many domains, there is no presumption on the part of research 'purchasers' that academic work should have a premium over research that can be sourced from private providers. Purchasing decisions are based on the standing, reputation, pricing and track record of researchers, irrespective of the sector in which they are located. In the area of government-commissioned research and consultancy, the market is highly contested and governed by onerous procurement arrangements.

A further challenge for university research centres wanting to do interdisciplinary research is that academic structures, financial incentives and individual rewards make the venture hazardous.

Academic researchers working in interdisciplinary research centres undertaking commissioned research and consultancy also confront a major problem, in that their research output might not be recognised under current research infrastructure funding arrangements or research quality assessment schemes.

3.1.3 Government- and industry-funded centres

There has been growth in research centres established as collaborations between business and/or government and research organisations. Such centres are becoming increasingly common in practice-oriented disciplines, such as engineering, information and communications technology (ICT), finance and public policy.

In recent years, governments have recognised a need to build research capacity and capability for industry development and public policy by funding research centres of excellence. Notable examples include:

- the Australian and New Zealand School of Government
- the National Drug and Alcohol Research Centre
- the Strategic and Defence Studies Centre at the Australian National University
- the United States Studies Centre at the University of Sydney
- the Queensland Climate Change Centre of Excellence.

Some funding arrangements are quite substantial.

Research centres have been established around the expertise of highly accomplished academics. They are often staffed with people who have strong industry backgrounds, but sometimes experience problems in recruiting people from industry and government. Apart from salary differentials, people outside academia often do not meet the merit criteria for appointment to senior faculty positions. This differs from the situation in the United States, where there is a two-way flow of personnel between government (and business) and the academy. Recruitment practices in Australia also make it difficult to engage part-time and casual staff.

In some research centres, tensions emerge between academic and end-user motivations, values, behaviours and cultures. Centres are also often criticised for being diverted to academic priorities or orienting missions along trajectories that reflect researcher interest and expertise.

3.2 Cooperative research centres

The CRC Program has been the Australian Government's major vehicle for promoting collaborative research links between industry, research organisations, education institutions and government agencies. The program was established in 1990, with the first CRCs announced in 1991.

CRCs are a special category of industry- and government-funded research centres. They involve a 'tripartite' commitment and contribution by government, research organisations and industry partners. Funding is competitive, based on a 'business case' put forward to an assessment committee that addresses both research excellence (rigour) and the potential application of research in business and industry.

Initially, the CRCs were intended to build bridges between CSIRO and the universities. Industry involvement came later in the development of the model. The vision was for each CRC to be a 'one-stop shop' for innovation, consisting of a cooperative team of researchers and research users drawn from various organisations. Each CRC was to be large enough and capable enough to have a real and continuing impact in its field.

The case for CRCs was also based on a view that corporate research and development (R&D) was not well developed in most Australian industry sectors, which meant that corporate and other research users had limited capacity to benefit fully from the skills and information in the universities and government research organisations, notably CSIRO. Because information and technology are transferred most effectively when both parties have a similar level of knowledge, the lack of in-house business R&D capability was seen as an important liability.

The CRC model was based on the principle that research organisation participants would undertake mainly long-term strategic research (work at the 'R' end of the R&D spectrum) and research users would work mainly at the 'D' end. All user participants would have access to the research in the centre, so the competitive challenge for the individual firms that contributed cash and time to the CRC would be to utilise the research results before public release and so be ahead of others. There was no specific requirement that research should be interdisciplinary in orientation, although that has tended to occur in practice.

CRCs are accredited for doctoral supervision and also play an important role in training in science and engineering research (and to lesser extent social science research), providing skilled people for business in-house R&D capability.

The objectives of the CRC Program have evolved over time, following several reviews and growing government interest in the commercialisation of research, as reflected in a number of key industry statements. The current objective of the program is:

… to enhance Australia's industrial, commercial and economic growth through the development of sustained, user-driven, cooperative public–private research centres that achieve high levels of outcomes in adoption and commercialisation.

This focus on commercialisation is a major departure from the original purposes of the CRC Program. Many CRCs have taken this objective to mean generating a revenue stream from the commercialisation of research through sale and/or licensing of intellectual property in the form of products and services, or in the creation of research-based spin-off companies. This form of adoption and application of research findings is relatively easy to measure but, as a 2003 review pointed out, national and industry benefits that follow from broad take-up and adoption can be significantly greater, if much harder to measure (Howard Partners 2003).

There is a growing expectation among some parties that CRCs should be sustainable over the longer term and should cease to need government support. A number of CRCs have continued after government funding has been withdrawn, with their viability and sustainability assured by continuing investments from industry partners. However, the idea that CRCs will become self-sustaining through commercialisation revenue is probably unrealistic. Attempting to reach that goal could become counterproductive, giving rise to protracted intellectual property negotiations, wasting staff time and increasing administrative costs.

With the expectation of commercialisation outcomes, CSIRO, Australia's research-intensive universities and some state departments of primary industries have become circumspect about involvement in CRCs. There is also a concern that CRCs have become too complex and overhead-intensive and are now too focused on commercial development rather than on strategic research. CRCs' commercial focus is problematic, as a range of competitive, commercial and freedom-to-operate issues arise that have no real solutions in a multiparty joint venture.

A recent Productivity Commission report on public support for science and innovation in Australia concluded that the CRC Program is best suited to longer-term collaborative research arrangements, not commercialisation (Productivity Commission 2007). The commission identified a suite of complementary options for business collaboration with public-sector research agencies and universities that could provide more nimble, less management-intensive, arrangements. The commission was also concerned about the level of public subsidy provided to industry partners.

There was also reluctance within the then Department of Education, Science and Training to see the CRC Program, which the department administered, fund policy research that was the responsibility of other Australian Government and state government agencies. For example, there was an argument that CRCs involved in research relevant to a specific portfolio, such as the environment or agriculture, should be resourced by that portfolio. However, the CRC Program has had the effect of building policy research capability *across* portfolios and across jurisdictions. The Biosecurity CRC is a significant example.

The new Australian Government has indicated that it will reorient CRCs to their original objective of national and industry benefit. The reorientation is timely, as gaps are being identified in 'basic' or fundamental knowledge for broad industry and public policy development — for example, as a basis for developing strategies in animal and plant health and the environment. Those gaps have important cross-disciplinary dimensions.

The CRC system could be improved by including in its mandate a charter to contribute to the resolution of important public policy problems and issues, by implication through using an interdisciplinary approach. 'Industry' partners could include government departments and agencies.

The system could also be improved by government legislation or regulation for a CRC management vehicle — in the same way it has for pooled development funds. This could substantially reduce CRC formation costs, which are generated and captured by lawyers, accountants and taxation advisers.

3.3 Publicly funded research agencies

Interdisciplinary research is becoming increasingly important in the government-funded research agencies, such as CSIRO, the Australian Institute of Marine Science, the Defence Science and Technology Organisation, and the Australian Nuclear Science and Technology Organisation.

The CSIRO Flagships program draws multidisciplinary research capabilities from across CSIRO and supplements them with research and delivery skills from many partners in universities, other publicly funded research agencies, and industry. There are now more than 250 industry partners and research collaborators involved in the Flagships.

A central platform of the Flagships program is the development of strong, ongoing and outcomes-focused relationships that will result in beneficial and practical returns for the Australian economy. Research users and researchers are expected to work together to ensure that technologies are successfully applied and adopted.

The Flagships initiative has been an important CSIRO strategy to lead Australia's innovation effort in industries where Australian companies have had a relatively low commitment to R&D (food) or where there has been relatively low adoption of research (health and water). Research in those areas has been multidisciplinary and has had very few industry partners. It has tended to focus on broad societal benefits, such as nutrition and food safety, and adoption by government organisations and agencies, including public hospitals and health services and public enterprises in the water industry. The performance of those service-oriented industries is, of course, vital to Australia's economic, social and environmental future.

This shift in direction within CSIRO creates both further diversity and a different form of collaboration in the Australian innovation system. It suggests the emergence of a *coalition* form of organisation in research, providing for a greater commitment to leadership and direction than is the case in research *collaborations*, which reflect a more network-based institutional arrangement.

The Flagships program was reviewed during 2006 by a panel consisting of eminent research scientists, a senior university researcher, a CSIRO senior executive and two science consultants. The review panel strongly endorsed the model and found that the Flagships are delivering powerful scientific solutions to national problems (Batterham 2006). The panel also concluded that the model has had a profound positive impact on the culture and processes of CSIRO.

3.4 Government 'in-house' research capability

During the 1970s and 1980s, a great deal of the policy research effort was undertaken 'in house' in departmental research divisions and bureaus. That research was essentially problem-oriented, with agendas set by departmental research committees.

During the 1990s, in the spirit of public expenditure management and control, outsourcing and considerations of market contestability, departments' in-house policy research capability was either dismantled or severely constrained. Research bureaus and divisions were abolished or integrated. Examples include the Bureau of Industry Economics, which was 'integrated' into the Productivity Commission. The Productivity Commission has a focus on economic research, but a limited ability in cross-disciplinary research.

After the downsizing of government research divisions and bureaus, researchers moved to universities or joined (or started) private consulting firms.

Just as government departments have largely lost their internal capacity for research, the idea of a strategic research portfolio has also nearly disappeared. Departments without a research capacity find it difficult to commission research effectively and to establish and nurture relationships with universities or private providers.

Very few Australian Government departments or agencies appear to have a research strategy that addresses current and emerging policy issues, contains priorities, and commits funding.

Remaining departmental research bureaus and divisions include:

- the Bureau of Rural Sciences
- the Australian Bureau of Agricultural and Resource Economics (ABARE)
- the Bureau of Infrastructure, Transport and Regional Economics
- the Bureau of Tourism Research.

The Department of Agriculture, Fisheries and Forestry has retained research infrastructure in ABARE and the Bureau of Rural Sciences, which have a major role in advising government on agricultural resource policy and rural science policy. Both organisations are heavily focused on interdisciplinary research.

The Bureau of Tourism Research continues as part of the Department of Infrastructure, Transport, Regional Development and Local Government.

Some other departments also maintain a strong internal capability for research, including the Treasury; the Department of the Environment, Water, Heritage and the Arts; the Department of Families, Housing, Community Services and Indigenous Affairs; the Department of Foreign Affairs and Trade; the Department of Innovation, Industry, Science and Research; and the Department of Resources, Energy and Tourism.

Like R&D divisions in the private sector, many internal research bureaus are being required to work on a cost-recovery or rate-of-return basis and compete with external providers, including universities, publicly funded research organisations and private sector consulting firms. To the extent that bureaus have limited access to funds for capacity building and 'researcher-initiated' inquiry, there is currently little capacity to focus on some of the more fundamental trends and concerns behind public policy problems and issues.

With an easing of restrictions on recruitment, departments are increasing their employment of staff who have research roles, and there is some evidence that recruitment has been focused on employing people with high-level, cross-disciplinary research skills. For example, there are now significant numbers of people with PhDs employed in some of the major policy agencies in Canberra.

Many program areas within government have people working on research issues, but mainly from a specialised functional and disciplinary perspective. While program managers are active in commissioning research to support policy development and program design, this does not appear to be undertaken as part of a departmental research strategy. Such research is often commissioned as a consultancy through the government's procurement process.

The procurement process is increasingly rules-based and creates a major limitation on the capacity of departments to secure leading-edge innovation policy perspectives. To get the best-informed advice, departments need to be prepared to invest in the relationship with the research providers, whether they are from universities or are private consultants. One-off projects tightly hedged in by restrictions do not, in the long term, provide the best returns.

3.5 The private sector

The outsourcing of policy research capability across all areas of government — economics, social policy, environment, mining, industry, transport — has seen the emergence of a wide diversity of interdisciplinary research providers (and brokers). Universities are but one group of players in this market.

The private sector is now a major supplier of policy research for government and industry. Private providers include specialist consulting firms in areas such as economics and social policy, and the global consulting firms that specialise in management and evidence-based strategy.

Private providers are able to respond to problems and issues on an interdisciplinary basis either from within their own organisations or in collaborations and strategic alliances with other organisations, sometimes including universities.

The capacity of the private sector to provide research capability is constrained by government purchasing policies that focus on value for money and probity. All government 'purchases' must go through a time-consuming, resource-intensive, lawyer-driven procurement process. This can be expensive and very high risk for suppliers. Panel arrangements set up by corporate units within departments have tried to reduce costs, but program managers are not obliged to use them (DoFA 2006).

This regulatory regime limits incentives and opportunities for private-sector research providers to develop business models and invest in capabilities that would provide a distinctive competitive advantage, and that would meet public sector research needs and requirements.

3.6 Conclusions

This section has reported on the infrastructure for interdisciplinary policy research in Australia. It has identified capacities and capabilities, as well as strengths, weaknesses and gaps in a range of structural, systemic and institutional arrangements.

Systems approaches to innovation assume that institutions can be self-directing and self-correcting. It is clear, however, that investments in capability are needed to improve system performance and outcomes.

In view of the demands and expectations for a 'scholarship of integration' in both industry and government, there is a need to ensure that policies and programs to support this form of user-driven inquiry are both appropriate and adequate. There must be structures and systems in place to ensure that this aspect of the innovation system meets the needs of industry, government and the academic community.

Contrary to the views of some commentators, who see a convergence between the interests and missions of government, industry and the academy (Etzkowitz et al 1998; Leydesdorff et al 1998ab), a considerable investment is required to build the structures, systems and behaviours that would support a 'scholarship of integration'.

Neither government, nor universities, nor industry has been willing to encourage, support and nurture the capacity of Australian researchers to undertake interdisciplinary research, which is most likely to enhance industrial innovation and provide the evidence base for informed and effective public policy.

Chapter 4

Policies and practices for effective interdisciplinary research

This section reviews current and possible future funding and delivery models for interdisciplinary research that addresses industry and public policy needs. Strategies include encouraging all government departments to develop research strategies, and promoting changes in university structures and systems to encourage interdisciplinary, problem-oriented research that can provide evidence for policy development and program design and delivery.

4.1 Competitive funding for interdisciplinary work

If government wants researchers to address national problems and issues in an interdisciplinary way, it is going to have to fund that activity. The characteristics of interdisciplinary research pose special challenges for established funding organisations that wish to support it, notably in the evaluation of research proposals. Interdisciplinary research is typically collaborative and involves people of disparate backgrounds, and dealing with the cultural differences between disciplines can make it slower and more expensive to carry out.

The ARC and the NHMRC should continue to fund researcher-initiated inquiry and seek to enhance interdisciplinary research projects built around curiosity and discovery. Their contribution is not only in supporting the continued advancement of knowledge, but also in training researchers who might subsequently work in policy areas in government and research in industry. This is quite likely: recent work by the Group of 8 shows that about 45% of PhD graduates are in positions outside the university or research sector when surveyed 5–7 years after graduation.

Reliable methods for prospective and retrospective evaluation of interdisciplinary research and education programs may require modification of the peer-review process to include researchers with interdisciplinary expertise, in addition to researchers with deep expertise in the relevant disciplines.

It would not be appropriate for the ARC or the NHMRC to fund user-initiated industry/government research agendas. Those initiatives should be driven and funded by industry, government, or both.

4.2 Better structure, incentives and rewards in university systems

The emergence of arrangements to fund interdisciplinary research, particularly in the public policy arena, will affect the way universities respond to the need and opportunity for interdisciplinary, problem-oriented, user-initiated research.

Universities will still need to focus on strengthening discipline areas, but at the same time focus on *research domains*. This point is made in a recent report from the European Commission (EC 2006; see box).

In attempting to balance the strengthening of disciplines and the pursuit of interdisciplinary research, education and training, many institutions are impeded by traditions and policies that govern hiring, promotion, tenure and resource allocation. Those matters will need to be addressed at the institution and overall 'innovation system' level.

Enhance interdisciplinarity

Universities should be able to reconfigure their teaching and research agendas to seize the opportunities offered by new developments in existing fields and by new emerging lines of scientific inquiry.

This requires focusing less on scientific disciplines and more on research domains (e.g. green energy, nanotechnology), associating them more closely with related or complementary fields (including humanities, social sciences, entrepreneurial and management skills) and fostering interaction between students, researchers and research teams through greater mobility between disciplines, sectors and research settings.

All this necessitates new institutional and organisational approaches to staff management, evaluation and funding criteria, teaching and curricula and, above all, to research and research training.

The implications of interdisciplinarity need to be acknowledged and taken on board not only by universities and Member States, but also by professional bodies and funding councils, which still rely mostly on traditional, single-discipline evaluations, structures and funding mechanisms.

European Commission

4.3 Broadening the CRC model

The CRC Program (see Section 3.2) was established in 1990 to boost Australia's industrial, commercial and economic growth by developing sustained, user-driven, cooperative public-private research centres that achieve high levels adoption and commercialisation.

The CRC Program links researchers with industry to focus their R&D efforts on progress towards utilisation and commercialisation. The close interaction between researchers and the users of research is a key feature. Another feature is the industry contribution to CRC education programs to produce industry-ready graduates.

CRCs have worked well in the creation of knowledge relating to 'national benefit' and 'broad industry' (collective) benefit. Industry-focused CRCs have also been responsible for the creation of a small number of viable and sustainable new businesses in new markets and potentially new industries.

There has been a tendency for the CRC Program to focus on knowledge creation and transfer in the natural and life sciences and ICT; there have been very few CRCs in the social sciences and none covering the humanities.

With the growing relevance of interdisciplinary research to address major public policy issues, and the contribution of the social sciences and humanities to that work, the charter for the CRC Program should be broadened to cover applicable research emanating from what the EU refers to as the 'socio-economic sciences and humanities'. To the extent that the research users are government departments and agencies, a condition of funding would be that those organisations be full joint-venture partners in the CRC.

Departmental resources for a CRC would be included in and supplied under departmental research plans.

If this foreshadowed change takes place, CRCs would be supported where they have a clear focus on research that creates foundation knowledge useful and applicable in addressing major industrial and public policy issues. That research may be interdisciplinary, and would be research not normally done by business *or* government acting alone.

4.4 Adapting the RDC model to other industry areas

The research and development corporation (RDC) model is a unique partnership between the Australian Government and rural industries. The rural RDCs address national and specific rural priorities, develop internationally competitive and sustainable practices, and promote dissemination of innovative products and processes in the agriculture sector. The RDC approach is administered under the *Primary Industries and Energy Research and Development Act 1989*.

Key features of the RDC model include:

- independent, skills-based boards charged with taking a strategic approach to rural R&D
- a national and integrated industry approach to R&D priority-setting, with a strong focus on outcomes and end-user needs
- strong industry involvement throughout the R&D process
- funding of a broad scope of rural research activities
- a strong outcome focus
- dual accountability to industry and the government
- funding by industry levies, with matching government funding.

Over the period of the RDC model from 1990–91 to 2004–05, industry contributions rose from $61 million to $234 million a year. Australian Government contributions rose from $95 million to $205 million a year. Since 2000–01, industry investment has been larger than government investment, reflecting industry commitment to rural R&D. Total R&D expenditure in 2004–05 was over $511 million.

The model has expanded in recent years, with the development of industry-owned companies that have assumed the functions of the RDCs and industry marketing bodies—such as the mergers of the Australian Meat and Livestock Corporation and the Meat Research Corporation to form Meat and Livestock Australia Limited.[1]

Two of the RDCs are not centred on a particular industry but instead focus on national issues of consequence to all rural industries: the Rural Industries RDC addresses the needs of smaller and new and emerging industries, while Land & Water Australia focuses on natural resource management.

Land & Water Australia

The great majority of our research is commissioned research, being research that is managed under commissioned programs which are aimed at meeting identified R&D priorities which have been determined through consultation with stakeholders.

Research and development is a vital component of the continuing process of developing new attitudes towards, and practices in, natural resources management. Land & Water Australia provides a national focus for awareness of key R&D issues in natural resource management.

The corporation also makes funds available for R&D to build the necessary knowledge base, and to ensure that knowledge is applied to improve management practices.

Land & Water Australia does not operate as a research grants scheme. R&D results or scientific publications are not the primary focus of the corporation's activities. The final aim is the achievement of innovation in the form of improved and more sustainable management of natural resources.

1 The R&D corporations are the Cotton RDC, the Fisheries RDC, the Grains RDC, the Grape and Wine RDC, Land & Water Australia, the Rural Industries RDC and the Sugar RDC.

The (industry-owned) R&D companies are Australian Egg Corporation Limited, Australian Pork Limited, Australian Wool Innovation Limited, Dairy Australia Limited, Horticulture Australia Limited, Meat and Livestock Australia, Australian Livestock Export Corporation Limited (LiveCorp) and Forest and Wood Products Australia Limited.

When evaluating R&D proposals, we ensure that the R&D to be supported has been incorporated within an innovation process with strong involvement by those who will implement the research results. In some cases, as much attention and funding may be directed to the communication and adoption of research results as to the technical R&D itself. It is important that researchers understand that we manage our R&D portfolio as an investment activity using public funds to achieve significant public benefits.

We support R&D in three basic ways:

- commissioning specific work from research or other organisations that have demonstrated they have the expertise to meet the specified objectives in the required time
- seeking tenders against tightly specified outcome and objective statements from groups that may be able to do the work (Commissioned Research)
- where there is room for different approaches, or in the case of strategic or basic research, seeking applications through an open call (Innovation Call Research).

In each case, a two-stage evaluation process is generally used. This involves an initial expression of interest from the researcher or research organisation. This focuses on the purpose and specific objectives of the work, and provides evidence of the close involvement of resource managers.

A Land & Water Australia program manager will then liaise with successful applicants to provide feedback on the expression of interest and to enable them to provide a full application.

The second application has a much stronger focus on the research methods to be followed and the past performance of the research group involved. As part of this assessment process, applicants should review their applications against the provisions of the Environment Protection and Biodiversity Conservation Act.

The second-stage application is forwarded to scientific referees, and the program management committee in making its final decision on funding then reviews their comments, together with the application.

Land & Water Australia

The RDCs are well regarded by the primary industries sector and seen as a possible model for other sectors.

One downside is that, while RDCs are generally good at strategic, *industry*-relevant research with a strong market or potential market focus, they do not address some of the *policy*-relevant questions for government — such as the evidence required for the eradication of exotic animal and plant pests and diseases, which involves fundamental research and inquiry.

The reported success of the rural RDC model in stimulating user-driven, strategic and interdisciplinary research has prompted many people and organisations to advocate its broader application across other industries. However, the RDC model works in rural industries because the industries are well organised and accustomed to collective approaches. There is broad acceptance of the compulsory levy system.

Industries in the manufacturing and services sectors are generally less well organised, and in many cases highly fragmented. However, the opportunity for collaborative research is greater where there are strong industry organisations that have moved past adversarial industrial relations agendas and are capable of developing productive relationships with research organisations.

4.5 Lessons from overseas: the RTO model

In the United Kingdom and Europe, industry and professional associations have formed 'research and technology organisations' (RTOs) to provide an interface between industry and the university sector.

Research and technology organisations

In the United Kingdom, industry research and technology organisations (RTOs) provide an important interface between industry and the university sector. This role goes back to the 1920s and 1930s, when university–industry interactions were far fewer than they are today. RTOs vary widely in their genesis, longevity, modes of governance and sources of finance.

There is now a substantial body of academic research that highlights the key role played by interface organisations that mediate university–industry interactions. As Dodgson and Bessant observe, '… research and technology organisations (RTOs) working on a sectoral basis are playing an increasingly important role, not just in generating technology or providing technical services to members but also in identifying, understanding and articulating user needs, and tailoring suitable solutions to these needs.' (Dodgson and Bessant 1996: 183).

These interface, or buffer, organisations have evolved as a means of reconciling the incompatibilities between universities (and other essentially academic organisations) and profit-driven industry. As such, they help to absorb the 'stresses and strains' that occur in university–industry interactions which arise from the different missions of each type of organisation.

Some RTOs have their roots in professional and trade associations, others developed from regional economic development initiatives, others stem from central government initiatives. Indeed, some of these interface capabilities are provided by universities themselves. Although there is wide diversity in the type of organisation involved, they share the characteristic that they provide a bridge between the distinctive objectives of universities and industry. They often have a sectoral focus.

In Europe, the RTO sector accounts for about 14% of total R&D expenditure, and for about 40% of total government expenditure on R&D in EU-15 (and probably more in EU-25). It is heterogeneous in organisation: public research centres, private non-profit associations, arm's-length managed agencies. It is also variable in the functions which individual RTOs perform: basic research, applied research, policy support, big infrastructures, and certification. The RTO framework is also continually evolving with the privatisation of public laboratories, joint ventures with universities, and growing commercialisation of services to industry.

Scholarly research concerning the roles of intermediaries in innovation has focused on these research and technology 'interface' organisations (Howells et al 1998; Howells (2006).

There has been only limited investigation of the applicability of RTOs in the Australian context. The closest parallel is AMIRA International Ltd, an independent association of minerals companies that develops, brokers and facilitates collaborative research projects. The arrangement provides a vehicle for a number of companies to jointly fund research and jointly share the benefits. The combined funding enables AMIRA to recruit the world-leading researchers to address industry problems and opportunities and to conduct sustained research, which leads to the development of a stronger industry research base.

With the notable exception of the AiGroup and the Australian Business Chamber (through the Australian Business Foundation), Australian manufacturing and service industry associations still tend to be focused on industrial relations and workplace issues rather than on supporting and promoting innovation among members. A number of associations commission research projects to assist them in their lobbying and advocacy roles. The results of that research are often reflected in policy decisions and implementation.

The option to extend the rural RDC model to other industries has been raised many times, but a major stumbling block is obtaining industry agreement to a levy system, which is effectively a tax on production. It is really up to industry leaders to promote the benefits of industry-wide research to their members on the basis of the importance of lifting overall industry performance and enhancing international competitiveness. The wine industry is often cited as example of the benefits of industry-wide research through the Grape and Wine RDC (Marsh et al 2000).

4.6 Conclusions

Competitive research funding systems favour curiosity-driven, researcher-initiated and disciplinary research. Current ARC interdisciplinary funding rarely supports significant funding across sectors, and the funding process leaves it largely to researchers, not industry or government, to identify the research questions.

Integrated, or interdisciplinary, research tends to be strategic and problem-oriented. This is evident in the funding arrangements for the rural RDCs and industry-initiated centres of excellence. The rural RDC model provides a capacity to address industry-defined research questions on a interdisciplinary basis. The RDCs have a weakness in not being able to address government problems and issues. In some cases, the creation of industry-owned corporations to take over their work has increased that weakness.

The CRC model, as it is currently constituted, does not effectively support strategic research agendas. The responsible government minister has indicated a preference to return to the 'original' purposes of the CRCs. This provides an opportunity to address national policy issues and problems from a genuinely interdisciplinary perspective.

In public policy contexts, *government* should define the 'big picture' policy research issues and fund projects that can be undertaken at those facilities. This is what CSIRO does with its facilities and through its Flagships program.

Outside the remit of the CSIRO, there is a need for a whole-of-government *research* policy framework that provides guidance for individual portfolio research strategies.

Chapter 5

Conclusions

This section outlines proposals to initiate an R&D policy for government, including research plans at the portfolio level, and a strategic approach to use interdisciplinary research to inform policy development.

5.1 A research and development policy for government

With a growing commitment to evidence-based policy and the emergence of a number of 'big picture' policy problems that require interdisciplinary approaches for their resolution, there is a requirement for government to adopt and implement an R&D policy—in a manner that parallels commitments in Australia's major mining, manufacturing and service industries.

A number of agencies already have a commitment to strategic research, such as the Department of Defence through the Defence Science and Technology Organisation, which supports R&D to build Australia's defence capability, and the Department of Agriculture, Fisheries and Forestry, which supports ABARE and the Bureau of Rural Sciences. In other departments, research capability has been run down or eliminated to deliver expenditure savings, based on a belief that adequate research can be sourced from the universities or the private sector.

Universities and the private sector may have a capacity to respond, but the practice of sourcing research through the Australian Government's procurement process provides little incentive for them to invest in capability to deliver high-quality, relevant and applicable research for policy development and implementation. Moreover, the procurement process severely limits the incentive to offer innovative approaches to resolve complex policy problems and issues.

The current processes for funding university research centres within existing academic structures and incentive and reward systems do not necessarily deliver evidence in a form and format that is useful for policy decision and action. These issues are currently a major topic of debate in management research, where a wide gap is perceived between theory-based research in universities and the practice-based needs of managers (Pfeffer 2007). There is a similar gap between public management research and the practice needs of public managers.

Australian Government and state government departments should be required to develop research programs built on interdisciplinary principles, *and resource them* at levels that will ensure that ministers, policy advisers and program managers have access to knowledge and information that will ensure that policy actions and initiatives are based on sound evidence. This should involve the development of in-house capability and the maintenance of capability in the higher education and private sectors.

Only with some assurance of 'purchaser' commitment can universities be expected to commit themselves to developing strategies, creating structures and making changes to incentive and reward systems to meet the research needs of government. Similarly, the private research market needs some assurance of longer term demand as a basis for making decisions to invest in capacity and capability.

This paper has sought to bring together governments' need for evidence-based research to guide policy decisions and actions with the call for universities to make a greater commitment to interdisciplinary research. As many of the issues relating to interdisciplinary research, and many users of research results, are in the public domain, government can respond to the challenges by taking a serious approach to its own R&D requirements.

Development of a robust 'scholarship of integration' is as much in the hands of the users as it is in the domain of the providers.

5.2 A strategic approach

Researcher-initiated, curiosity-driven research mediated through a peer review system has the objective of expanding the frontiers of knowledge. The main vehicles for funding such research in Australia are the ARC, the NHMRC, internal university research funds (including the time of full-time academic staff) and philanthropic sources.

While research funding agencies mainly support researcher-initiated, curiosity-driven projects, government expects research not only to be excellent, but to also be relevant to economic, social and environmental outcomes as reflected in the National Research Priorities:

- An environmentally sustainable Australia
- Promoting and maintaining good health
- Frontier technologies for building and transforming Australian industries
- Safeguarding Australia.

Each priority has from four to seven associated priority goals — 21 in total.[2]

In the United Kingdom, the Comprehensive Spending Review Settlement for 2007 forms the basis of the Science Budget for the period from 2008–09 to 2010–11 (amounting to £11,240.3 million or about A$24 billion). The settlement sets out the long-term policy challenges that are to form the basis for research allocations and funding by the British research councils.[3] These are:

- demographic and socioeconomic change, with rapid increases in the old age dependency ratio on the horizon, and rising consumer expectations of public services
- the intensification of cross-border economic competition, with new opportunities for growth, as the balance of international economic activity shifts towards emerging markets such as China and India
- the rapid pace of innovation and technological diffusion, which will continue to transform the way people live and open up new ways of delivering public services
- continued global uncertainty, with ongoing threats of international terrorism and global conflict, and the continued imperative to tackle global poverty
- increasing pressures on natural resources and global climate, requiring action by governments, businesses and individuals to maintain prosperity and improve environmental care.

The Science Budget funds a number of cross-council programs that are intended to involve new ways of interdisciplinary working, and combining resources from a range of bodies. These cover energy, living with climate change, global threats to security, and ageing. The Science Budget also supports interdisciplinary projects in the digital economy and nanoscience.

Digital economy

The Digital Economy programme will link the world-class ICT research base with the other disciplines needed to deliver its benefits and match those with a strong user pull to deliver multidisciplinary, user-focused research aimed at building a base of expertise to put the UK at the forefront of the digital technology. Through the Digital Economy programme we will make a step-change in the type of industrial engagement to pursue key research challenges so that the transformational possibilities of ICT are employed to support the innovation cycle. The initiative (involving EPSRC, AHRC, ESRC, MRC, and STFC) will concentrate on areas where the management and presentation of information can have maximum transformational impact: healthcare, transport, and the creative industries.

Source: http://www.dius.gov.uk/publications/URN07114.pdf

2 See http://www.dest.gov.au/sectors/research_sector/policies_issues_reviews/key_issues/national_research_priorities/default.htm

3 See http://www.hm-treasury.gov.uk/media/6/F/csr_longterm271106.pdf

Transformational impacts of digital technology are also particularly important in the humanities, where multimedia presentation can supplement and replace text presentation.

By contrast, Australia does not have a science budget or innovation budget that sets out policies and priorities for research funding agencies, research organisations and government departments that fund research. The closest we have is the *Backing Australia's Ability* statement.

5.3 Portfolio research plans and strategies

In the interests of government services innovation, evidence-based policy, informed program design and improved service delivery, *all* Australian Government departments should have research plans and strategies that address critical policy problems and issues through the creation and application of new knowledge. Commitment to R&D should be seen to be as important for public sector organisations as it is for private sector corporations.

Given the importance of research to policy formulation, implementation and review, there is a strong argument for a whole-of-government research strategy. Such a strategy would set objectives, establish priorities and provide guidance for the development of portfolio research plans.

Portfolio research plans and strategies should be funded as a required element in overall portfolio budgets. Plans would identify areas for research investment, research programs and actions, and provide for reporting on performance. This system would reflect practice in the United States and emerging practice in Australia, where some portfolios have developed and funded their own research strategies, for example in energy.

It would be up to portfolios to decide how to invest their research budgets. For example, they might build in-house capability, contract with CSIRO and other public research providers, contract with private research providers, create new research organisations (like NICTA), or contract with established university research centres.

Portfolio research plans should require annual reporting and accountability to Parliament in much the same way that portfolios are required to report their governance and compliance arrangements to the Australian Public Service Commission, Parliament, etc. The public system would parallel corporate requirements to report on R&D expenditure.

Overall, ministers and departments should be encouraged to build research capability in the sectors or domains in which they operate, *not in academic disciplines*. This would mean building up the capacity of departments and agencies to undertake and/or fund research according to their own research strategies and priorities.

Governments accept that policy should be driven by evidence, which implies an investment in research and the creation of coherent strategic plans. Some portfolio areas may have accepted this idea in principle, but been slow to take steps to implementation. It may require determined action by government to ensure that the evidence-driven policy approach is implemented by all portfolio areas.

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