Australian Research Council

SUBMISSION TO INQUIRY INTO BUSINESS COMMITMENT TO R&D IN AUSTRALIA

September 2002

AUSTRALIAN RESEARCH COUNCIL

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SUMMARY OF SUBMISSION

The importance of R&D to national economic, social and cultural development has been well demonstrated. National Innovation Systems (NIS), within which a country's R&D activity occurs, vary in terms of their strengths and weaknesses. The strength of Australia's NIS is its high quality public sector research, focussed primarily on basic research. The major weakness of Australia's NIS is the relatively low level of investment by business and industry in R&D. There are many reasons for this and they are discussed in this submission.

When considering how to address this weakness in our innovation system there are two main options. We can provide incentives to businesses to conduct R&D in house through offering direct grants and indirect incentives such as the R&D tax concession. Alternatively, we can improve the interface between the public sector providers of research and the users of that research in the business and industry sectors, so that industry is more ready and able to take up and commercialise the research outcomes from Australia's publicly funded research effort. A third variation is that we concentrate on growing new high technology businesses through the formation of start up companies spun out from our universities, medical research institutes and CSIRO. A recent study commissioned the ARC, the National Health and Medical Research Council and CSIRO indicates that this sector of our economy is growing. (More detail on the findings from this study can be provided to the Committee later in September 2002). These options are not mutually exclusive, however, and it may be appropriate to pursue all three approaches to improving Australia's business R&D effort and, therefore, our overall national R&D effort.

In the context of the ARC's role as the key provider of agency support for university research, the key emphasis in this submission is on the importance of partnerships and linkages between the providers of high quality university research and the users of that research in the business and industry sectors. Some impediments and barriers to higher levels of commercialisation of university research, both external and internal to the university sector, are discussed and specific suggestions are provided for improving the interface and therefore the functioning of Australia's innovation system.

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1. INTRODUCTION

On 16 July 2002, the Federal Minister for Science, Peter McGauran announced the terms of reference for a parliamentary committee's inquiry into the Australian business community's commitment to research and development (R&D). The terms of reference for the inquiry comprise three questions:

- What would be the economic benefit for Australia from a greater private sector investment in R&D?;
- What are the impediments to business investment in R&D?;
- What steps need to be taken to better demonstrate to business the benefits of higher private sector investment in R&D?

This submission from the Australian Research Council (ARC) focuses primarily on the first of these questions, but also offers some comment, in the context of boosting university industry partnerships, on the second and third questions.

About the Australian Research Council

Established under its own Act, the Australian Research Council (ARC) is an independent agency within the Education, Science and Training portfolio, tasked with providing strategic advice to Government on research and research training, administering the Commonwealth Government's significant direct investment in higher education research through a portfolio of investments supporting research projects, programs and centres as well as individual researchers and teams of researchers. The ARC also plays a role in brokering links between higher education research and other contributors to the national innovation system, including the business sector. Membership of the Board of the ARC is broadly representative of the national innovation system.

The Australian Research Council, through the National Competitive Grants Program, allocates funds to either investigator-initiated research proposals or to targeted research on a competitive basis via an internationally benchmarked system of peer assessment. The ARC supports research in science, engineering and new technology through to social sciences and humanities. The ARC is a key provider of agency support for university research, providing about half of all national competitive grant support.

This Submission

The structure of this submission comprises, firstly, a discussion of the economic importance of research followed by a discussion of what constitutes an effective national innovation system and the complementary roles of the various players, such as industry and universities, in such a

system. This is followed by consideration of the structure and functioning of Australia's innovation system and its strengths and weaknesses. Recent research findings on public and private sector research and the critical nature of their interaction are used to emphasise the importance of R&D to achieving successful business outcomes, particularly in the knowledge-based economy of the future. The key factors in enhancing the commercialisation of university research are identified and discussed. Finally the role of the ARC in innovation is considered, including its brokerage role between researchers and the users of research and particular approaches for achieving this are discussed.

2. AN INNOVATIVE AUSTRALIA

The spirit of discovery and innovation is a long-established Australian tradition.

Potter's Flotation Process

In 1901, Melbourne chemist and brewer Charles Potter developed a way of separating valuable metals from crushed rock by using bubbles to lift them to the surface of a liquid. Australia's flotation process is used for practically every mineral mined and is the most widely used method of extraction in the world. Along with the cyanide process and the Bessemer process, it is considered one of the three greatest advances in metallurgy in the past thousand years.

Walsh's Atomic Absorption Spectrophometer

In 1952 Dr Alan Walsh discovered that the light which atoms absorb – even when the atoms are in their normal state – could be measured precisely. Walsh's discovery opened the door to a new world of chemical analysis and a host of practical applications in a range of fields that has saved lives and significantly advanced the globe's war against pollution.

By 1954, Walsh had designed his atomic absorption spectrophometer which has been adopted by scientists and technicians in almost every field of work throughout the world.

Potter's flotation process and Walsh's atomic absorption spectrophometer are just a sample of Australian innovation which has shaped the world in many fields for many years. The rewards for Australia and Australians have been rich with major advances in health, quality of life, industry and economic prosperity.

The evolving information age, however, has changed the rules and recipe for economic security and social advancement. Knowledge and ideas are becoming the world's most valuable commodities. A successful transition from a predominantly natural resources-based economy to a knowledge-based economy is necessary to ensure that Australia holds its place as one of the world's great nations.

The success of Australia as a knowledge-based economy will depend on our ability to:

- generate new knowledge, ideas and technologies through research;
- convert them into real economic and social benefits; and
- broker successful partnerships between the providers and users of research at the national and international level

These factors are now considered more critical to business success and national economic performance than the availability of the traditional productive factors of land, labour and capital.

3. THE ECONOMIC IMPORTANCE OF RESEARCH AND DEVELOPMENT

Research is one of the major drivers of Australia's economic growth and competitiveness in the global market. A number of economic studies have concluded that there is a clear link between technological progress and economic growth, both at the level of the individual firm and the economy more generally. One analysis estimated that 49 per cent of economic growth came from technical progress[1] and another found that every 1 per cent increase in a nation's investment in research increased productivity by 0.23 per cent.[2]

There is significant private return on some R&D investment at the firm level, but due to spillover benefits there is a much greater social return. A survey of 63 international studies found annual rates of return on R&D in the order of 20 to 30 per cent to firms and approximately 50 per cent to society overall.[3] The large difference between the private and public rates of return on R&D leads, in the absence of adequate public investment and government action, to under-investment in R&D. Investing less than the optimal level means that economic growth will be slower than otherwise attainable.

Recent empirical research has established that corporate R&D is strongly associated with subsequent gains in companies' productivity, earnings and stock prices.[4] The research demonstrated that patent application citations and the links to science in those patent applications are significantly associated, after controlling for conventional financial variables, with subsequent market-to-book ratios and stock returns.

The continuum that ends with significant jobs growth in new industries begins with research activity which, through links between the providers and users of research, enables industry to seize the benefits of new knowledge. Together with the training and provision of highly skilled people able to recognise applications of new knowledge, research and development leads to greater employment opportunities, economic growth and enhanced quality of life for all Australians.

Concentrations of economic activity involving innovative firms, universities and public research institutes can act as magnets for new technology, skilled personnel and investment in research. They emerge in circumstances where there are critical masses of firms to allow economies of scale and scope, where there is access for these firms to a strong science and technology base, and where there exists a culture conducive to entrepreneurship.

The Importance of Publicly Funded Research

The US Government has long known that publicly funded research is the foundation of technological advancement and therefore economic and social gain. Recent evidence from studies carried out in the US and Australia by Narin *et al*, which link patents – as indicators of innovative activity in the economy – to publicly funded research, indicates not only the economic importance of publicly funded basic research but also the continuing importance of traditional methods of disseminating the results of that research, through publications in academic journals.

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[1] Boskin, M.J. and Lau, L.J. 1992, Capital, Technology and Economic Growth, in Nathan Rosenberg, R. Landau, and D.C.Mowery (eds), Technology and the Wealth of Nations, Stanford University Press. CA.
[2] Coe,D. and Helpman, E. 1995, International R&D Spillovers, European Economic Review, vol 39.
[3] National Science Board, 1996, Science and Engineering Indicators.
[4] Zhen Deng, Baruch Lev, and Francis Narin (1999) Science and Technology as Predictors of Stock Performance, Financial Analysts Journal, 55 (3), May/June 1999.

A study carried out by Narin in 1997,[5] which examined 397,000 patents in five industrial countries, found that:

- 73 per cent of the patents cite publicly funded research; and
- 52 per cent cite university research funded through agencies such as the ARC.

Notwithstanding the relatively low levels of Australian patents, a similar study for Australia by Narin *et al* and published jointly by the ARC and CSIRO in 2000 found an even higher relationship between patents and high-quality publicly funded research:

- 97 per cent of citations in Australian-invented US patents are to papers authored at publicly funded institutions - 45.5 per cent to papers authored at universities;
- Of all Australian-authored scientific research papers cited in 1988–97 US patents, the ARC and the NHMRC are the individual organisations most frequently acknowledged in those papers; and
- The only countries which had higher science-linked patents than Australia are Israel, the USA and Canada. [6]

The Importance of Research Excellence for Technology Development

A 2000 study by Chi Research[7] found that the papers cited in US patents are drawn preferentially from the most highly cited, highest-quality research. More specifically, a U.S. paper in the most highly cited 1% of scientific papers is 9 times more likely to be cited in a patent than is a randomly chosen U.S. paper.

A policy conclusion, which can be drawn from these data, is that scientific excellence and innovation are closely linked. The fact that highly cited papers are much more likely to be cited in patents suggests that scientific excellence and contributions to innovation go hand in hand. In other words agencies like the ARC, which support the best research, will support the research most likely to contribute to innovation. Conversely when mediocre research is supported, for whatever reason, neither science nor innovation is likely to gain much direct benefit. This is true across all scientific fields and in both basic and applied research. The results imply that governments and private sector companies that fund the best science have the best chance of reaping technological benefit.

The clear message from these studies is the necessity for a broad-based foundation of basic research of the highest quality. Australia must capitalise on its research strengths if it is to be a successful and prosperous knowledge-based economy. A foundation of basic research excellence is vital to sustain leading edge innovation.

4. A HIGH PERFORMING INNOVATION SYSTEM

Nations have different capacities to encourage innovation, reflected in the behaviour of their firms, the institutions that foster innovation and the policies of government. A properly functioning National Innovation System (NIS) underpins the innovative capacities of business

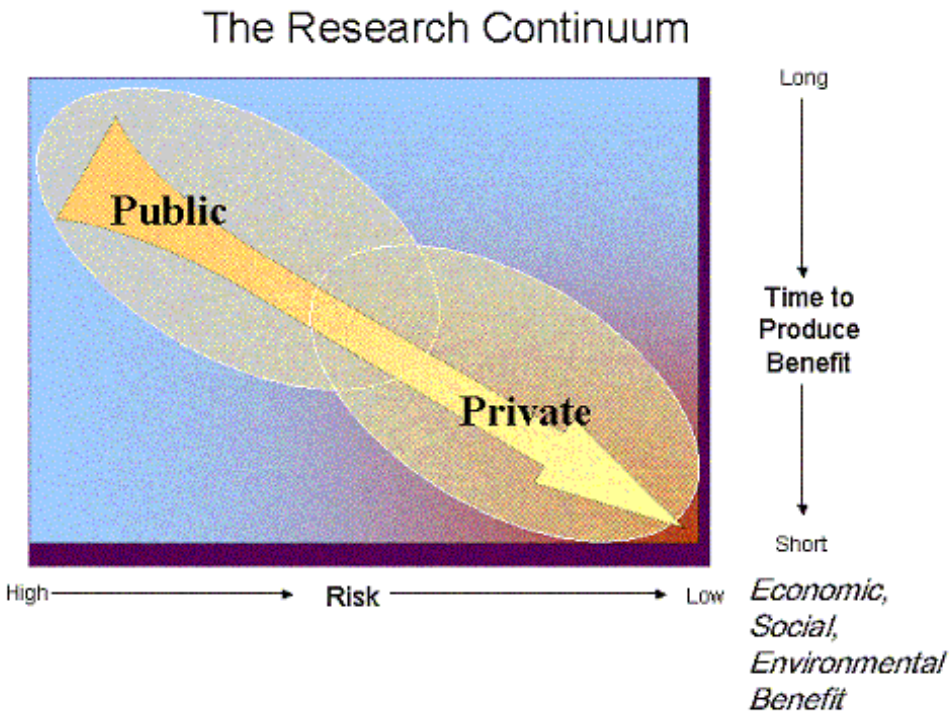
[5] Narin, F. 1997, The Linkage Between Patents and the Scientific Literature, from proceedings of Conference Knowledge Production, Patents and Technological Intelligence, 23 October 1996, Canberra.
[6] Narin, F. et al, *Inventing Our Future*: *The link between Australian patenting and basic science*, ARC and CSIRO, Canberra, 2000.
[7] *CHI's Research, Vol. VIII, No.1 - July 2000* (<http://www.chiresearch.com/docs/nltviii1.pdf>).

and industry by providing collectively what firms cannot individually produce or afford themselves. This is especially true in small countries with small firms that have too few resources to meet the costs of research of a more basic kind.

The Research Investment Continuum

Research ranges from high risk with a long time to deliver benefits, to low risk with a short delivery time. Investment in research is provided by the interplay of public and private interests along this continuum, both in parallel and in sequence. Government investment is essential at the upper high-risk end of the continuum. Private sector investment will increase as risk and delivery time falls. It is essential that government policy and subsequent programs are directed at ensuring a smooth transition along this continuum. Life cycle support, which is both in parallel, and sequential to the research phase will maximise the benefits to the community from its investment. Gaps along this continuum contribute to an innovation system in Australia that performs below its potential.

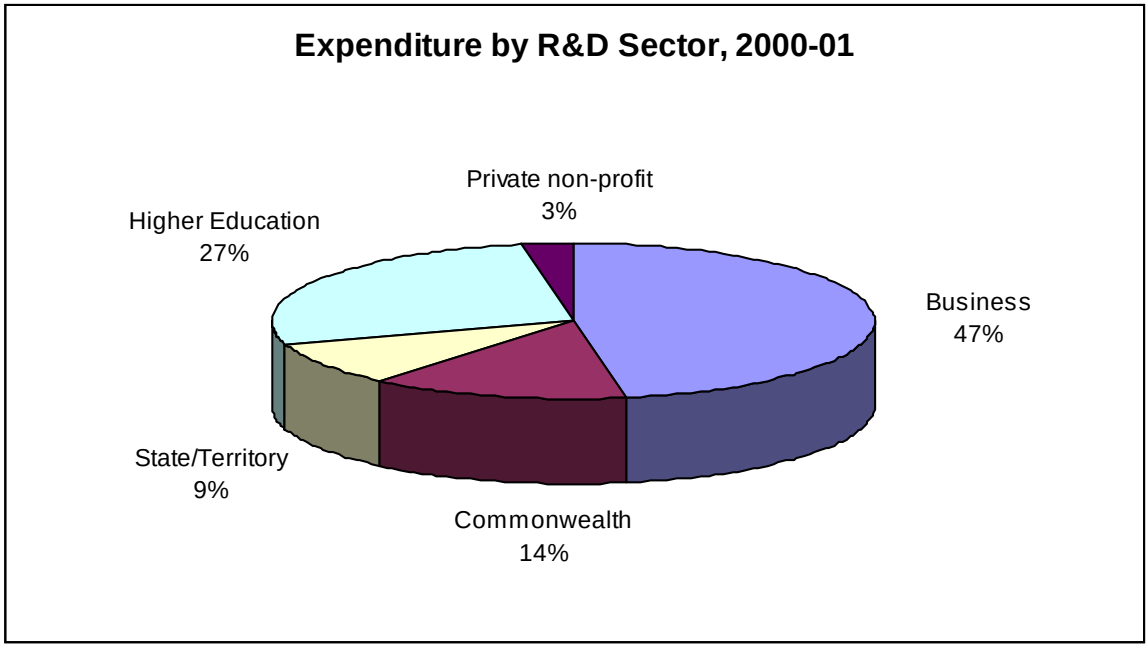
Figure 1



The Structure of the Australia's Innovation System

The structure of Australia's innovation system in terms of research expenditure by sector for 2000-01 is illustrated in Diagram 1.

Diagram 1



Business expenditure on R&D (BERD) is the largest single component of our innovation system. However, when compared with our OECD peers, it is characterised by a comparative paucity of BERD. Table 1 indicates our ranking of 11 out of 15 OECD countries for business expenditure on R&D.

Table 1

Australia's Expenditure on R&D

	Percentage of GDP	**Ranking**
Higher Education Expenditure	0.41%	6/17countries
Government Agencies Expenditure	0.35%	3/14 countries
Business Expenditure	0.72%	11/15 countries
Source: ABS Catalogues 2000-2001		

A common view is that this low level of investment in BERD is offset by our comparatively rich support for public sector R&D (GOVERD), where Australia ranks 3 out of 14 OECD countries and higher education expenditure on R&D (HERD) where in 2000, Australia ranks 6th out of 17 countries.

Industry research can be carried out in house, contracted out or a combination of the two. The most recent major inquiry into R&D in Australia was conducted by the Industry Commission in 1995. In its report the Commission noted that the research that is undertaken by business in Australia, is generally of an applied nature and product/process specific. Therefore, a key role for industry in Australia is the D in R&D whereby, through partnerships between industry and public sector research organisations, the research outcomes from public sector research are commercialised by being developed by the industry sector, with the benefits of that activity shared according to the terms of the deal struck by the parties.

The Industry Commission report also found that there are several macro economic reasons for Australia's low BERD/GDP ratio. Foremost among these is decades of insulation from international competitive pressures, as a result of geographic isolation and high tariff protection. Other issues are the relatively small size of the manufacturing sector in Australia and its low-tech nature.

The Industry Commission report also discusses a common view that Australia's low BERD/GDP ratio is because it has one of the lowest levels of government support for business R&D. The report concludes that whilst the level of direct support by Government through grants or loans is low by international standards it provides one of the highest overall levels of support when both direct and indirect support, through tax credits and concessions, is considered. Next to Canada Australia provides one of the highest levels of support for non-defence business R&D.[8]

Many of these factors and the policy settings have changed in the period since the mid 1990s when the Industry Commission carried out its inquiry. The Australian economy has continued to open up and new Government programs to stimulate R&D, both private and public, have been put in place. After several years of relative decline, business expenditure on R&D has increased by 18 per cent for the period 2001-02.

Programs across various Commonwealth Government agencies are addressing some of the gaps in our innovation system by fostering interaction between universities and industry. Some such as the CRCs, R&D START and the ARC's Linkage program have been tailored specifically to encourage this interaction. As interactions between universities and industry increase in scale and become more complex, there is an onus on government to ensure that programs within and across different agencies are responsive to emerging needs. What has been lacking to date, is an effectively coordinated effort to forge links between these activities and integrate life cycle support for innovation in ways that will deliver enhanced outcomes. Coordination mechanisms should serve to facilitate the evolution of collaborative partnerships by assisting them to make the transition between programs of support.

5. COMMERCIALISING RESEARCH OUTCOMES

Commercial outcomes may derive from research conducted by businesses themselves, via start up companies and/or the licensing of intellectual property from public sector researchers such as the universities and CSIRO, or from overseas. Research commercialisation is a complex and heterogeneous concept, requiring complicated interactions between research providers, the companies wishing to exploit the outcomes from research and, in many cases, the investment sector. In its most obvious form, the commercialisation process involves taking laboratory scale research results and completing the considerable further experimental development, production and marketing that is needed to deliver new products and services to consumers. While it can

[8] Industry Commission, Report of Research and Development, Canberra, 1995.

generate substantial economic benefits, research commercialisation is a costly process. For every dollar that leads to a promising research outcome, anything up to a 100 dollars or more of further investment may be required for successful commercialisation. Experience in Australia and overseas indicates that only one in one hundred of prospective research outcomes investigated for investment purposes can be successfully commercialised.[9]

Australia's major strength is its publicly funded excellent science base, conducted in government research organisations and universities. It is imperative that this competitive advantage be maintained and enhanced. However, while a strong science system is critical to the generation of new knowledge, gaining full benefits from this knowledge requires greater levels of commercialisation of that research and is a vital aspect of any national innovation system. In the past, Australian discoveries and inventions have been allowed to wither, or have been lost offshore, because they were not transferred effectively to Australian industry. It is vital that we identify the key factors that lead to successful commercialisation of the outcomes from research. Some of the key factors are:

- A paucity of industry receptors;
- Venture capital and taxation regime;
- Linkages between industry and public sector research organisations;
- The innovation progression gap.

Industry Receptors

An industry receptor is a company that has the capacity to understand, develop and bring to market the results of public sector research. Many foreign owned companies do not undertake research and development in Australia and if they do, the technology strategies are often developed at corporate headquarters overseas. This means those decisions taken overseas as part of global technology strategies can have a major impact on Australia's innovative capacity. According to some commentators Australian industry does not often look 20 or 30 years ahead to see the "new" technology. It tends to be timid about exploring new opportunities and reluctant to stretch itself financially.

One way for Australia to address this low industry receptor capacity is to create new ventures such as spin-off companies to exploit university and other publicly funded discoveries, rather than relying on licensing IP to existing businesses. A recent study jointly commissioned by the ARC, NHMRC and CSIRO found that for 2000 an encouraging number of start up companies were formed from our publicly funded research organisations. The report from this study, which benchmarks Australia's performance against that of the US and Canada, is expected to be made public during September 2002 and could be provided to the Inquiry at this time.

Venture capital and taxation regime

Until recently the taxation regime in Australia, particularly with respect to capital gains tax (CGT), worked against the attraction of venture capital (both overseas and domestic) for the commercialisation of research. However, the reforms to the CGT, announced by the Government in response to the Ralph Review of Business Taxation, go some way to rectifying this problem. However, the effects on business expenditure on R&D of the reduction in the

[9] Department of Industry, Science and Tourism, 1998, Science and Technology Budget Statement 1998-99.

company tax rate and the reforms announced by the Government to the R&D tax concession in 2001, as well as the interaction between these two factors, need to be evaluated.

Linkages

The best way to transfer knowledge or technology from the performers to the users of research, is to transfer people. If you don't have this capability then it is very inefficient to transfer knowledge from one organisation to another.

It is vital that appropriate mechanisms and incentives are in place to ensure that industry has the best possible access to skilled people and cutting-edge public-sector research. The ARC's experience with its Linkage program, which provides the opportunity for universities to link with an industry partner in seeking public funding, indicates that many businesses acknowledge the critical importance of forming partnerships to carry out high quality basic research. In 2002, 736 industry partners have co-invested in ARC sponsored research projects, resulting in $1.75 pledged by industry for every $1 invested by the ARC.

The ARC has found that, through its Linkage program, the opportunity for a postgraduate student to work on a collaborative research project for a cash contribution of as little as $5000 is particularly attractive to small to medium sized firms. A 1999 review of the Linkage program indicated that 51% of the industry partners in the postgraduate student element of the Linkage program were small to medium sized enterprises.

Outcomes from ARC funded research – some highlights

In 1965, Professor Graeme Jameson began his research in the theoretical field of multi-phase processes. Supported by the ARC for a number of years, the application of his research results was funded by the Australian Minerals Industry Research Association. In 1986, Professor Jameson was granted a patent on his mineral processing technology. The world rights to sell this technology were licensed to Mt Isa Mines in 1989 and since then the technology has become the standard in Australia for retrieving fine coal from tailings.

The commercial value to Australia of this technology research in 1997 and by 2000 the technology is in excess on $500 million in export coal each year.

The last time you bought melons, nectarines, peaches or plums you probably examined them for firmness and bought them hoping the taste would live up to the appearance. It's hit and miss. Now there is a way for producers to be able to guarantee the sugar content of fruit without taking a chunk out of it. This is a result of a test developed by a company called Hortical, a joint effort between Central Queensland University and Victorian company, Colour Vision Systems. The ARC first supported the collaborative was ready for the marketplace. Fruit sorted by Hortical's system is used with fruit marketed through Woolworths and Coles Export of the technology is being examined.

The Innovation Progression Gap

One of the handicaps faced by those researchers who are interested in commercialising their research is the "innovation progression gap", which is the gap between the outcomes of an ARC grant, for example, and early stage venture capital. Seed funding is needed to provide proof of principle, to exemplify patents, and to prepare business plans. The Commercialising Emerging Technologies (COMET) program and a new Government program specifically targeted at providing pre-seed funding for commercialising public sector research, as well as the Uniseed fund run by the University of Melbourne and the University of Queensland, are helping to address this gap, but a gap still remains for very early phase commercialisation, such as developing a prototype. As a complementary initiative, an additional stream within the ARC's

Linkage program could also be developed which would enable a university researcher to seek funding to commercialise an outcome from a Linkage project, which involves an industry partner. This could be done in situ or by the researcher spending time outside the university working with the industry partner. The ARC believes these initiatives could be implemented for less than $30 million per year.

Other factors which inhibit higher levels of research commercialisation and which relate to the internal workings of the university sector are:

- R&D management skills
- Intellectual property management; and
- University funding arrangements and reward systems.

R&D Management Skills

Most university researchers are not entrepreneurs and they do not want to learn how to become entrepreneurs. However, there are also some researchers who have the aptitude and taste for entrepreneurship and who might be the best people to commercialise their own inventions. But effective management is critical for the day-to-day operation of a business, implementation of research, development of marketing programmes, securing funding and intellectual property strategies. Australia has a shortage of skills and experience in these areas. Programs are needed which enable and encourage researchers and research students who would be entrepreneurs to acquire these skills and put them into practice.

Intellectual Property Management

Funding bodies in Australia, such as the ARC, recognise the Common Law right of universities as employers to the intellectual property arising from grant funded research. Therefore, the ARC does not currently play an active role in either causing the research funded under its schemes to be commercialised. It does, however, in association with other funding agencies such as the NHMRC, cause the universities receiving such funding to comply with a national policy for the management of IP from federally funded research.

A model for achieving significant change in the culture in Australia towards the commercialisation of university research could be to ensure in the conditions of award for an ARC grant that the researchers hold the license to exploit the IP arising from the research. This could stimulate more entrepreneurial behaviour by researchers by motivating them to seek financial rewards. Whilst there are risks associated with this approach, the key to its success is to provide support to researchers in exploiting their know-how, in exchange for a share of the royalties.

University Funding Arrangements and Reward Systems

The dominant reward system in universities can act as a major cultural barrier to the commercialisation of university research. Universities need to have flexibility to offer options to researchers pursuing commercial lines of work. A more decentralised industrial relations environment in universities would allow institutions to tailor terms and conditions of employment and reward structures to suit the particular circumstances and needs of collaborative ventures involving institutions and business partners.

A more far reaching structural option for facilitating collaboration between universities and industry is the introduction in Australia of the American practice at research institutions of allowing staff to earn funds above their normal salary for up to three months each year, often through consultancy agreements with industry, establishing a spin-off company or through the conduct of research funded through the National Science Foundation (NSF) or the National Institutes of Health (NIH) or another source.

This practice, however, needs to be seen within the broader context of the American system for funding research, particularly funding the salaries of the chief investigators on research projects funded externally by the NSF and NIH. To implement this approach in Australia would require the identification of the salary component of the universities' operating grant which can be attributed to research and its referral to the ARC and the NHMRC, which in turn would assume responsibility for funding the relevant proportion of the salary of the chief investigator in the projects they support. Notwithstanding the challenge of implementing this approach, there is little doubt, based on the American experience, that the flexibility it affords to staff to supplement their earnings through a number of ways, assists to establish crucial links with industry and makes the process of crossing from one type of organisation to another much easier. The American practice of scientists leaving their research work to champion its commercialisation is made easier by the fact that the route back again is easier than in Australia.

6. THE ROLE OF THE ARC IN INNOVATION

The ARC promotes innovation by:

- promoting and supporting research excellence;
- developing and facilitating linkages within the innovation system;
- benchmarking Australia's performance against international best practice;
- brokering interaction and collaboration between researchers and the users of research.

An example of the brokerage role played by the ARC is a project which would make available to venture capitalists information held by the ARC on research which has been judged as being high quality and which is likely to deliver national benefit. Access to this information could assist venture capitalists to make decisions about whether or not to pursue the owners of intellectual property of research sponsored by the ARC, with a view to investing in the commercialisation of that research. By making this information available through a searchable database, the ARC would be performing, in the national interest, the role of a broker between the performers of the highest-quality basic research in Australia and the users of that research. The dissemination of this information could be expected to improve the rate of commercialisation of university research, contribute to an improvement in the investment by the Australian business. sector in R&D and promote innovation in Australia. A summary of the outputs from a sample of ARC supported research projects is presented is presented below.

Information Goldmine of Excellence

At any one time the ARC is supporting 4 -5000 high quality research projects, across its two main funding programs – Discovery and Linkage. On average, each Discovery project involves 6 researchers and by the end of the project delivers 14 journal articles or books. 3% deliver a patent by the end of the project. On average each Linkage project involves 6 researchers and by the end of the project delivers 5 journal articles or books. 30% deliver a patent or have a patent pending by the end of the project.