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Australian Framework for the Commercialisation of University Scientific Research

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Abstract *Australia spends proportionally more on university R&D, particularly when compared with business expenditure on R&D, than almost any other advanced economy, which suggests that creating the right environment to encourage the commercialisation of Australian university research results is vital if Australia is to obtain the best economic results from its investment. In this paper a meta-analysis is used to review literature from various sources available on the broad environment in which university research commercialisation is conducted in Australia in order to identify the key components of the environment and where change may encourage or promote better commercialisation outcomes.*

Keywords: Australia; universities; research; R&D; commercialisation.

Introduction

The Australian Government has provided significant support for the commercialisation of research conducted in universities and publicly-funded research agencies, certainly since it announced its *Backing Australia's Ability* package in 2001[1] in an attempt to improve outcomes in this area. There is evidence that it has been successful in raising commercialisation results,[2] an outcome that is important because 'This Government believes that innovation—developing skills, generating new ideas through research, and turning them into commercial success—is key to Australia's future prosperity'.[3]

Drawing on the considerable body of literature on this topic, and secondary sources, this paper undertakes a meta-analysis to identify the major components that make up and influence the Australian university research commercialisation environment and identifies a number of important weaknesses in this environment. Some comparisons are made with regimes in comparable jurisdictions: the United States, the United Kingdom and Canada. The first step involves classifying the major components of the Australian research commercialisation system into the three domains developed by Tornatzky *et al.*:[4] mechanisms and facilitators;

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institutional enablers; and boundary spanning systems and structures. Within these groupings the characteristics of each major element of the system are described and analysed and, finally, there is a summary of the areas where change may assist in improving the Australian university research commercialisation system. This paper finds that there are some significant structural issues facing Australia's university research commercialisation system that require attention and remedy from a range of government agencies and from representative entities in the tertiary education and business sectors.

The issue of university research commercialisation is particularly important in the Australian context because so much of Australia's research is conducted within universities. Australia has one of the lowest BERD[5] investment rates in R&D, and one of the highest GOVERD and HERD investment rates amongst developed nations.[6] This results in Australian universities generally performing a larger proportion of national R&D than occurs in most comparable economies, which suggests that making university research commercialisation effective is an important element in maintaining Australia's innovative ability.

It may be useful to make a distinction between three issues that often become inter-twined and are sometimes difficult to separate. These are, first, the role and importance of innovation in an economy; second, public support for research (and, sometimes, development) at universities, in publicly-funded research organisations, and by private entities; and, third, the implications of commercialising university research. The relative importance of university research commercialisation as a driver of the national economy is often assumed, but there remain little hard data, and some significant scepticism as to the accuracy of the assumption.

Nations view technological innovation as an important component of the national economy: the United States' *American Competitiveness Initiative*[7] being a prominent example of such a programme which aims to maintain America's 'competitive edge in the world economy … [with] focused policies that lay the groundwork for continued leadership in innovation, exploration, and ingenuity'; likewise in Britain through its White Paper, *Excellence and Opportunity—A Science and Innovation Policy for the 21st Century*;[8] and Canada in its policy, *Achieving Excellence: Investing in People, Knowledge and Opportunity*.[9] Similarly in Australia, the Australian Government has examined the importance of innovation,[10] as has the business peak body, the Business Council of Australia.[11] Innovation, whatever its source, is the driver of continuing economic development and growth.

Continuing public funding of research at universities and publicly-funded research agencies remains the policy approach in advanced economies: the United States,[12] the United Kingdom,[13] and Canada[14] as well as Australia.[15]

The somewhat more controversial issue appears to be the extent and nature of the benefits that accrue from the commercialisation of university research. Overall, universities do not appear to achieve significant income from commercialisation,[16] but benefits other than income are claimed from the commercialisation of university research, as noted later.

Technological development and diffusion, whether in the form of innovation, investment in research and development or university research commercialisation, is influenced by a range of legislation, programmes, policies and other settings. It is not intended in this paper to examine the economic efficacy of government intervention on innovation, public support for R&D and university research commercialisation, which has been examined by scholars elsewhere,[17] but to assume its necessity, as governments in every advanced economy appear to do. It is the

purpose of this paper to identify the principal elements of the university research commercialisation environment in Australia and what could be done to effect improvement in some aspects.

Outlining the Australian Environment

Australian university research may be categorised conveniently into three major areas:

- medical and health sciences and biological sciences;[18]
- other science disciplines;[19] and
- all other disciplines[20] (including humanities, arts and social sciences, or HASS).

This trifurcated nature of Australian university research is evident in the funding allocated to each: of the $3.43 billion expended in university research in 2002–03,[21] $1.27 billion was spent in medical research, $1.22 billion in science disciplines, and $0.94 billion in all other research including HASS.

Comments in this paper concentrate upon the commercialisation of university non-medical scientific research because Australian university medical research has established itself already as successful by most measures, while it is unusual (but not unknown) for HASS disciplines to generate tangible intellectual property capable of protection and commercial exploitation.

In 1998 the Australian Research Council (ARC),[22] at the request of the then federal Minister for Education, Training and Youth Affairs, prepared a substantial report dealing with the commercialisation of university research: *Research in the National Interest: Commercialising University Research in Australia*.[23] In this report ARC defined the commercialisation of Australian university research as (p. 18): '… a complex and heterogenous [sic] concept, requiring complicated interactions between research providers, the companies wishing to exploit the research, and—in many cases—the investment sector. It is a key aspect of innovation'.

Enthusiasm to engage in commercialisation has developed among Australian universities since the early 1990s. The reasons why Australian universities engage in commercialisation activities are succinctly described by the Department of Education, Science and Training (DEST) in its 2002 report, *Best Practice Processes for University Research Commercialisation: Final Report*[24] as follows:

- to facilitate the commercialisation of research for the public good;
- to promote economic growth;
- to forge closer ties to industry;
- to reward, retain and recruit faculty [academic staff] and students; and
- to generate income.

> All universities do it for the same five reasons; the mix is just different. And if you focus on the first four, you will get the fifth. If you focus on the fifth, you are likely to get nothing.

However, even at world best practice levels of publicly-funded research, financial returns to institutions performing the research rarely exceed 5–10% of total public research expenditure;[25] and this is achieved by only a few of the best institutions. Average financial returns to research performing organisations from

commercialisation represent less than 3% of recurrent research expenditure, and most universities achieve less than this.[26]

It is clear that the Australian Government expects universities to take economic advantage of the perceived benefits of research commercialisation.[27] However, there has been no research published that identifies the financial returns obtained by Australian universities from research commercialisation activities. The nearest is research commissioned by the Australian Research Council[28] which notes, *inter alia*, a social rate of return of 3% with a 10-year time lag arising '… from the generation of commercialisable intellectual property' (p. 70), which represents a rather modest return. However, this research has, itself, been the subject of adverse comment as over-stating the benefits obtained.[29]

With Australian universities unlikely to obtain any significant financial advantage from research commercialisation, the first four reasons noted by DEST in its 2002 report, must represent the most cogent reasons why university research commercialisation is important to the national economy and encouraged by the Australian Government. Such an approach is also consistent with views endorsed by the Association of University Technology Managers (AUTM), when it notes with approval comments by University of Michigan President Mary Sue Coleman when she said recently:[30]

> Many people are often confused about why we are interested in technology commercialization, in nurturing startup companies, and in facilitating more patents and license agreements. It is not about the promise of future revenues that might be generated from this activity … It is not about the money. … Technology transfer must serve our core mission: sharing ideas and innovations in the service of society's well-being.

Assessing the Environment

Tornatzky *et al.*, in their analysis of the role of universities in the knowledge economy,[31] suggest that there are three principal domains into which university–industry relations may be conveniently categorised, namely:

- *mechanisms and facilitators* of partnerships and economic development;
- *institutional enablers*, which primarily pertain to organisational culture and rewards; and
- *boundary-spanning* structures and systems.

This approach permits a coherent structure to be applied to the analysis of university–government–industry relationships, and it is these relationships that determine the effectiveness of universities as sources of innovation and as contributors to the national economy. Because it provides a coherent theoretical approach, this paper uses the same three principal domains developed by Tornatzky *et al.*, expanded somewhat to embrace not only the university but also the broader environment, to describe the Australian university research commercialisation system.

Mechanisms and Facilitators

Governments in Australia at national and State/Territory level have taken steps to encourage and promote university commercialisation. At the national level, the

Australian Government has three principal areas of activity that influence university commercialisation practices:

- legislation—enacted through the Australian Parliament on matters such as intellectual property;[32]
- fiscal and taxation policies—such as influencing the venture capital industry through fiscal and taxation incentives to undertake certain activities such as research, commercialisation and linkages,[33] through the general taxation regime which affects incentives to invest in commercialisation,[34] and by providing incentives to researchers to undertake commercialisation through schemes such as linkage grants;[35] and
- industry and general policies—which are reviewed, developed and implemented through two principal agencies: the Department of Education, Science and Training (DEST) and the Department of Industry, Tourism and Resources (DITR) and their respective predecessor agencies. In addition, the Australian Government has established entities which analyse and inform the government on particular issues relevant to commercialisation, such as: the Office of the Chief Scientist;[36] the Prime Minister's Science, Engineering and Innovation Council;[37] the Australian Biotechnology Advisory Council;[38] the Industry Research and Development Board;[39] the Co-ordinating Committee on Science and Technology;[40] the Rural Industries Research and Development Corporation;[41] and the Business–Industry–Higher Education Collaboration Council.[42]

Australia's eight State and Territory governments have been working to influence Australia's science and technology systems in a number of ways,[43] with commercialisation being influenced through two principal mechanisms:

- legislation—because, apart from universities in the Australian Capital Territory, it is State and Territory legislation that establishes and governs Australian universities; as well as which, States have legislative competence in important business areas such as partnerships, confidentiality and trade secrets; and
- fiscal policies—which are generally exercised through State and Territory agencies[44] responsible for industry development in such matters as financial incentive schemes.[45] To the extent that States and Territories have any policy impact it is usually manifest through fiscal means delivered through these agencies.

The Australian Government has implemented a number of programmes and actions designed to promote commercialisation,[46] including that of universities, such as:

- establishing the environment to encourage financing schemes such as Management & Investment Companies,[47] Pooled Development Funds,[48] the Venture Capital Limited Partnerships Program,[49] schemes to modify Customs Duty and GST imposts[50] and certain taxation benefits;[51]
- providing financing, to certain levels, at particular stages of development;[52]
- funding technology incubators;[53]
- funding university centres of commercialisation and entrepreneurship;
- encouraging the development of Co-operative Research Centres;[54]
- removing some taxation impediments to venture capital investment in Australia;[55]

- developing the Commercialisation Training Scheme, intended to train researchers in commercialisation;[56]
- the establishment in 1992 of the Australian Technology Group to provide early stage equity for ventures.

This is not to suggest that the Australian Government has developed and administers an ideal environment; academe and industry both suggest that there are fiscal and taxation matters that require some substantial review.[57]

The environment created by the Australian Government and described here largely aligns Australia with current international practice in the USA,[58] the UK[59] and Canada,[60] although, in many cases, several years after these other jurisdictions.

Consistent with the policy intention of the Australian Government under the *Venture Capital Act* 2002, as at 2006 most Australian States and Territories have enacted legislation to permit the formation of incorporated limited liability partnerships.[61] The special feature of an incorporated limited liability partnership is that there is no relation of agency between the general and limited partners.[62] Again, this desirable step represents less a radical innovation than bringing Australia more into line with international practice.

The Australian Government has funded, with industry, a number of university–industry co-operative research centres, CRCs, in the following fields (with the number of CRCs in each category as at March 2006):

- Manufacturing Technology (11);
- Information and Communications Technology (9);
- Mining and Energy (8);
- Agriculture and Rural Based Manufacturing (16);
- Environment (17);
- Medical Science and Technology (8).

Of the 71 CRCs funded in 2004, only 12, or 17%, cited a non-metropolitan address as their principal location,[63] suggesting a noticeable bias towards metropolitan and the more established and research-oriented universities.[64] Some analysis of the role and results of Australian CRCs has been published in academic journals by McFarlane[65] and by the Australian Government.[66]

In addition to the CRCs, as of 2004, Australia had a number of other university-affiliated research entities, comprising: six ARC Key Centres for Teaching and Research, eight ARC Centres of Excellence, eight ARC Centres, 16 ARC Special Research Centres, and 14 Rural Research and Development Corporations.[67]

The equivalent of CRCs can be found in other jurisdictions, for example Industry/University Co-operative Research Centres (IUCRC) and Co-operative Research and Development Agreements (CRADAs) in the US, Collaborative Research and Development in the UK,[68] and Networks of Centres of Excellence (NCEs) in Canada.[69]

Research on Australian commercialisation has tended to concentrate on a limited number of issues, such as the Australian Graduate School of Entrepreneurship at Swinburne University, which has conducted in-depth analysis of the spin-off company as the mode by which ideas can be taken to market;[70] and the involvement of SMEs in commercialisation.[71] The following observation made by Burgio-Ficca in 2001[72] remains substantially true in 2006: '… despite a growing body of literature on the benefits and/or spillovers of R&D, surprisingly little work has

been undertaken on the actual contributions of the higher education sector to R&D'.

Institutional Enablers

Australian universities have not, until relatively recently, systematically sought to exploit the outcomes of science research through commercialisation. Where exploitation of ideas happened previously it relied, substantially, on individual academic staff having either a peculiar entrepreneurial bent or a personal relationship with an appropriate industrial partner.

A recent but important development by most universities in systematising commercialisation is the creation by most universities of a commercialisation office (sometimes a commercialisation company).[73] The role of commercialisation offices varies between institutions but, in general terms, their role embraces some or all of the following activities:[74]

- educating and creating awareness of IP processes and requirements amongst researchers;
- assisting researchers with their IP and patent protection;
- assessing market potential;
- identifying potential industry partners and collaborators;
- negotiating license agreements;
- forming start-up companies; and
- finding investors and industry partners.

Analysis of the effectiveness of commercialisation offices has been undertaken overseas on many occasions,[75] but little research appears to have been undertaken in Australia.

In Australia, the University of Queensland commercialisation company, UniQuest[76] is one of the more successful commercialisation offices. Its charter is '… to identify, package and commercialise university technologies and expertise'.[77] UniQuest sees itself as having two major interfaces: with industry, business and government at one level; and with university researchers at the other. Amongst smaller Australian universities, Swinburne University has recently established its commercialisation abilities through Swinburne Knowledge, which states its role as being '… broadly to facilitate, support, and monitor some of the University's commercialisation activities'.[78] It says that, as a smaller university, it believes the best commercial returns are achieved through spinning-off companies. As at March 2006, UniQuest has a staff of over 50 plus a board of nine, while Swinburne Knowledge has three staff.

There may be more effective ways of structuring university commercialisation offices than the present one-office-per-university model, such as consolidating offices either geographically (so that one office operates on behalf of more than one university) or by discipline (so that one office may specialise in, for example, information and communications technology). A recommendation made by Lambert[79] was to the effect that universities should establish and share common services within regions to support technology transfer. An interesting recent development in Australia involves an agreement between UniQuest, located in Queensland, and the University of Wollongong, in New South Wales and some 1,000 km from Queensland, entered in November 2004, under which UniQuest assumes the lead role in commercialising research on behalf of Wollongong

University. This development is philosophically similar to Lambert's suggestion, but demonstrates that geographic proximity is not a pre-requisite to co-operation between universities; indeed, proximity, and the rivalry that arises from it, may be an impediment to sharing resources locally.

Intellectual property (IP) constitutes most of what universities have to commercialise. Protection of Australian university IP is governed by the general law—there is no Australian legislation specifically affecting universities such as the US *Bayh–Dole Act*[80] which reserves to universities ownership of IP developed from federally-funded research. Australian universities have acted to identify, protect and exploit valuable IP in two ways: through sets of agreed principles developed collectively by representative organisations; and through individual statutes, policies and procedures in each university.

There are two documents that have been developed by representative entities that have a major influence on IP management in Australian universities:

- the National Principles of Intellectual Property Management for Publicly Funded Research[81] (the 'National Principles'); and
- Ownership of Intellectual Property in Universities Policy and Good Practice Guide[82] (the 'Policy Guide').

The National Principles were drafted by parties that represent most major publicly-funded research interests in Australia, and are intended to apply to entities such as the Australian Government's Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Defence Science and Technology Organisation (DSTO), as well as universities. The National Principles were developed 'to assist researchers, research managers and their research institutions, in ensuring that they have access to best practices for the identification, protection and management of IP, and therefore, to maximise the national benefits and returns from public investment in research'.[83] But they have no force in themselves and, to be effective in individual universities, have to be adopted by incorporation into the IP policies and procedures of each university.

The Policy Guide was developed specifically for universities because the AVCC[84] observed (*Policy Guide*, page 6) that: '… ownership of IP in universities (13 February 2001) shows a diversity of practices as to views on copyright ownership'. The Policy Guide was developed to provide 'advice on how to deal with questions of ownership of intellectual property generated within the institution by staff, students, under agreements with outside bodies, and under grants or sponsorship'.[85] Like the National Principles, the Policy Guide has no force and effect in any university unless its recommendations are incorporated into individual university policies and procedures.

Just as the AVCC observed in 2001, it remains the case in 2006 that Australian universities have diverse policies and procedures affecting IP. Each university has its own set of IP policies and procedures, and no two appear to be the same. Few universities have adopted the National Principles (explicitly or by implication) and, notwithstanding the Policy Guide, there remains a diversity of approaches to IP ownership. The uncertainty bred by this diversity of approach to IP remains a matter of some concern to Australian industry.[86]

In response to concerns about diverse university intellectual property policies, Auril, Universities UK and the UK Patent Office published *A Guide to Managing Intellectual Property: Strategic Decision-Making in Universities*[87] to guide UK universities

on intellectual property management, but it appears that Canadian universities remain free to develop intellectual property policies as they see fit. This diversity in national approach to intellectual property management may arise from political influences in the various jurisdictions, or it may suggest that specific intervention is needed to overcome some inherent problem in the environment (as existed in the United States prior to the *Bayh–Dole Act*) but should, in any event, provide an interesting field of research over the next few years.

Almost certainly the most important component in successful commercialisation is the human component. The Australian Government has undertaken a survey of the university commercialisation environment in general,[88] as well as the particular issue of incentives for involvement in research commercialisation.[89] Without adequate incentives to engage in commercialisation, academic staff could not be expected to participate with enthusiasm. Incentives are of two principal types: those that provide a benefit to individual academics; and those that ameliorate some adverse consequence.

Benefits to academics may come in several forms, the most usual being relief from teaching obligations, monetary reward, enhanced reputation, and promotion. One of the most common benefits academic researchers receive is relief in their teaching load while they participate in industry-related activities such as commercialisation. The monetary benefit to researchers is generally described in individual university IP policies and procedures. Academic reputation increases, generally, from peer recognition, most usually from activities such as publication in reputable books and journals, and by obtaining grants and other income from research. There is often a potential conflict between the need to maintain some degree of secrecy in order to preserve IP rights and the need for academics to publish. Publications also have a significant influence on promotion prospects. The other factor influencing promotion is the weight (where it applies) given to commercialisation activities by universities when assessing academic staff for promotion.[90] Many Australian universities claim to value commercial activities when assessing staff for promotion, but whether this applies in reality needs further investigation.

Academic staff may be disinclined to engage in commercialisation unless potential adverse consequences are sufficiently minimised. Probably the largest of these is the cost of establishing IP rights and the financial risk attending commercialisation failure. Both of these consequences are significantly reduced for individuals when the university itself undertakes to obtain IP protection and becomes the entity that licenses IP or establishes the commercial venture to exploit the IP. The circumstances when individual universities will assume these costs and risks are prescribed in the IP policies and procedures of individual universities.

Boundary-Spanning Structures and Systems

Links between industry, financiers and universities are facilitated in Australia through entities such as:

- the Australian Institute for Commercialisation (AIC);[91]
- Knowledge Commercialisation Australia (KCA);[92]
- the Licensing Executives Society of Australia and New Zealand (LESANZ);[93]
- organisations representative of science and technology practitioners, such as the Federation of Australian Scientific and Technological Societies (FASTS)[94] and the Australian Academy of Technological Sciences and Engineering (ATSE);[95]

- the Australian Industrial Research Group;[96]
- on-line and other mechanisms to disseminate ideas from research and promote linkages between researchers and industry;[97]
- university commercialisation offices (in some cases, companies);
- co-operative research centres and similar entities;[98]
- the Australian Private Equity and Venture Capital Association Limited (AVCAL);[99]
- Business–Higher Education Round Table;[100] and
- industry associations.

The AIC, established by the Queensland State Government in 2002, is a national, not-for-profit company dedicated to enhancing Australia's ability to commercialise its research and development (R&D) in the global marketplace. The AIC provides assistance to industries performing R&D and innovation (not only universities), through a network of state-based representatives.

KCA is the peak body representing organisations and individuals associated with knowledge transfer from the public sector. Its purpose is to assist in the development and maintenance of skills associated with knowledge transfer from public sector organisations, and to promote the activities of its members in government, industry and commercial forums. KCA was formed in 1978 as the Australasian Tertiary Institutions Commercial Companies Association, was incorporated in 1993, and in 2001 became KCA. KCA is one of the foundation members of the International Federation of Technology Transfer Organisations, which was founded in 2004.

LESANZ is the local arm of the Licensing Executives Society, the international non-profit professional society whose members are actively involved in the transfer of technology and industrial and intellectual property rights. Its objectives include educating its members in professional and business skills; monitoring developments in licensing practices; publishing reports, studies, and statistics; facilitating contact between potential licensors and licensees; and sensitising governmental and international bodies to licensing issues.

FASTS, which represents the views of workers in Australian science, influences the formulation of science and technology policy in order to bring economic, environmental and social benefits to Australia. The societies which make up FASTS represent the professional interests of scientists and technologists in Australia. There are 66 member societies representing 65,000 individuals. The FASTS President is an *ex officio* member of the Prime Minister's Science, Innovation and Engineering Council.

The Australian Industrial Research Group was founded in 1964 with the objectives of improving the quality of research management in Australia and stimulating and developing an understanding of research as a force in economic, industrial and social activities. It has links with kindred organisations operating in other countries, such as the Industrial Research Institute (IRI) of the US, EIRMA (Europe), JATES (Japan), KITA (Korea), AIRI (Italy), and ANPEI (South America).

CRCs are represented through a collective body, the CRC Association, which was established in 1994. The CRC Association represents members' views on issues of generic importance to CRCs and their operation, and allows members to share experience and practices, and helps to promote awareness of CRCs and the CRC programme.

The Australian Private Equity and Venture Capital Association Limited (AVCAL) is the national association that represents the venture capital industry's participants, promotes the industry and encourages investment in growing business enterprises. Membership of AVCAL comprises venture capital firms, institutional investors, banks, incubators, angels, corporate advisors, accountants, lawyers, government bodies, academic institutions and other service providers to the industry.

The Business/Higher Education Round Table is a forum where leaders of Australia's business, research, professional and academic communities address important issues of common interest, to improve the interaction between Australian business and higher education institutions, and to guide the future directions of higher education.

There are also a number of links being created between individual financiers such as pension funds (that are generally prepared to finance longer-term opportunities) and research groups. For example Western Australia's largest pension fund, Westscheme, has offered funding for the development of university technologies through Uniseed (a joint venture between UQ Holdings/Uniquest and Melbourne University) up to $15 million, and with Murdoch University $12.5 million over 10 years.[101]

Some industry associations that have an interest in this area include:

- Australian Industry Group;[102]
- Australian Electrical and Electronics Manufacturers' Association;[103]
- Australian Telecommunications Users' Group;[104]
- Australian Information Industry Association;[105]
- Australian Computer Society;[106]
- Australian Interactive Media Industry Association;[107] and
- Australian Chamber of Commerce and Industry.[108]

Some other groups and associations that represent participants in research, development and innovation generally, include:

- ANZA Technology Network[109]—formed to connect Australian, New Zealand and US technology executives, showcase Australian and New Zealand technology companies and executives in the US, and to educate Australian and New Zealand technology executives on how to perform better in the US;
- Technology Parks and Incubators Association[110]—established to promote technology transfer, innovation and entrepreneurial growth in Australia, specifically through science and technology research parks and incubators;
- Innovation Exchange Network[111]—IXC provides a secure, managed environment for the connection of insights and opportunities between business, universities and governments through the deployment of skilled individuals (intermediaries).

Australia has a number of technology parks and incubators, some of them associated with universities. There appears to be little published research on the effectiveness of these precincts for the purpose for which they were established, although there is some anecdotal evidence on the effectiveness of incubators in helping new high-technology businesses survive the first few years of corporate life.[112]

Boundary spanning systems and structures exist in all advanced economies; many of them, such as the Licensing Executives Society, exist in each of them. However, Australia suffers a significant deficiency in terms of entities that assist in providing the bridge between research and industry. It is not alone in this. Industry Canada has recently recommended the establishment of a national Commercialisation Partnership Board[113] to supplement provincial efforts, while, on the other hand, the United States has had private sector entities involved in this for decades—for example, Battelle, a major participant, was established in 1929. Intermediaries are relatively new to the UK, a prominent example being the Scottish Intermediary Technology Institutes which were established in 2003[114] (although the UK has had research support through entities such as The Wellcome Trust[115] since the 1930s).

Conclusions

Australia dedicates a larger proportion of its research effort through universities than most developed economies. For the economic health of the country, and to maintain Australia's position as an innovative economy, it is essential that the results of this university research are deployed effectively. This means that structures and mechanisms should exist to promote and encourage the diffusion of research results in such a way that they can be used, whether through collaboration with business and industry, or through other mechanisms such as university spin-off companies. Generally speaking, business and industry undertake research in order to develop innovations of economic value, but this has not been the historical role of university research. Australia therefore faces a greater task than most economies, certainly when compared with the United States, in developing a system and culture that encourages and promotes something valuable—the diffusion of university research of economic value—from a system and culture in which this object has not, until recently, been a significant factor. Changing the values and orientation of universities (and businesses, for that matter) to exploit the potential economic value that universities are creating requires a co-ordinated and long-term effort on the part of government, business and individuals.

This paper has shown that the government and some business institutions in Australia have begun to establish the systems which may permit the potential economic value created through university research to be released. Because the process of innovation and economic growth is, itself, constantly changing, the task for all parties in this environment will never be static and requires constant review, analysis and re-orientation. For this reason, among many others, there is not and never will be a perfect system. From Australian federal and State/Territory Governments, university and business representative organisations, and from individual universities have evolved a set of legislative, fiscal and policy responses to this environment that attempt to encourage the better and more effective use of Australian university research; but there remain many areas where Australia remains behind comparable economies in encouraging and promoting the successful exploitation of university research for the betterment of the Australian community. From the analysis contained in this paper areas requiring examination include:

- a fiscal and taxation regime that requires substantial revision if it is to encourage research out of the university and into industry so that the development needed to make marketable innovations can be undertaken;

- the availability of capital early in the innovation cycle to ensure that promising ideas are able to move from the proof-of-science stage through early-stage development until they reach a point where they can become commercially viable;
- a cohesive intellectual property regime capable of being understood by all major participants: researchers, capital and industry, rather than the diversity of approaches currently taken by Australia's universities (notwithstanding the attempts by representative entities, however well-intentioned, to create national IP guidelines and policies);
- the need to develop university missions and policies supportive of research commercialisation; not least among them being consistent and realistic benefits to researchers; the recognition and implementation of commercialisation as a criterion for academic promotion; consistent and realistic policies dealing with conflicts of interest involving commercialisation activities; and the proper management of risks, especially commercial risks, involved in commercialisation and related activities (such as business ventures);
- correction of an apparent bias towards the established research universities at the expense of the non-metropolitan universities, unless such a policy is actively pursued as being necessary to obtain maximum benefit from available research funding;
- a need to undertake more research into the economic benefits gained by the Australian economy from university research in order to better understand this important part of the commercialisation system;
- evaluation of the effectiveness of the way in which Australian university commercialisation offices are being established, and the efficiency of those offices that have been established. It may be that the present ad-hoc approach of establishing one office per university is simply untenable for reasons of efficiency or lack of a sufficient number of qualified staff;
- independent analysis of the worth or otherwise of technology parks and incubators in an Australian context; and
- encouragement for the development of intermediaries to aid in bridging the gap between research entities and industry in order to bring the results of research to market more quickly and effectively.

One of the greatest contributions that all stakeholders in this environment can make to the change needed for commercialisation to work is patience inspired by taking a long-term view. It will take time to change attitudes and expectations amongst the various parties, to teach entrepreneurship to researchers, to develop strategies that are capable of evolving to meet changing technological and economic environments, and to permit stakeholders in the commercialisation system to gain experience in working together in a new way.

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20. For example: commerce, politics, accounting, history and law.
21. ABS 8112.0 expenditure by research field, for 2002–03, the latest year available.
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23. Australian Research Council, *Research in the National Interest: Commercialising University Research in Australia*, Australian Government, 1998.
24. Department of Education, Science and Training (DEST), Best Practice Processes for University Research Commercialisation: Final Report, DEST, 2002, at p. 47, quoting Louis Berneman in a tele-presentation to a Research Commercialisation Workshop for the Higher Education Review Secretariat, DEST, 1 August, 2002.
25. In 2000 there were six US universities and two Australian universities where licence income exceeded 10% of research expenditure: see Knowledge Commercialisation Australia, *Forum and Fair of Ideas Discussion Paper*, Knowledge Commercialisation Australia, March 2003, p. 5.

26. The Allen Consulting Group, 2003a, *op. cit.*; Bok, *op. cit.*
27. Hon Dr D. A. Kemp, Minister for Education, Training and Youth Affairs, *Knowledge and Innovation: A Policy Statement on Research and Research Training*, Australian Government, 1999; Australian Government, 2001, *op. cit.*
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29. Sinclair Davidson, 'Should government fund science?' Paper prepared for publication by Professor Sinclair Davidson, Dean (Research & Innovation) at RMIT.
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31. Tornatzky *et al.*, *op. cit.*, pp. 16–20. These authors, on behalf of economic development agencies in the Southern US, undertook an identification and analysis of the characteristics of the 12 best-performing US universities in terms of high-quality business–higher education partnerships.
32. In particular the following Commonwealth Acts: Patents Act 1990; Copyright Act 1968; Trade Marks Act 1995; Designs Act 2003; Plant Breeder's Rights Act 1994; Circuit Layouts Act 1989. Under section 51(xviii) of the Australian Constitution the Australian Parliament has power to make laws with respect to 'copyrights, patents of inventions and designs, and trade marks', which leaves State and Territory Parliaments to cover related intellectual property issues of confidentiality, trade secrets and such matters.
33. The number of Commonwealth and State fiscal programmes includes: 39 in commercialisation; 26 offering financing; 36 supporting linkages; six providing loans; 13 supporting regional development; 49 in R&D; 23 supporting start-up companies; and 23 promoting technology transfer/diffusion/uptake. Source: Department of Industry, Tourism and Resources, *Commonwealth and State Government Programs Supporting Innovation in Firms: At January 2003*, 2003, Index A.
34. In this regard, see especially: Cameron Rider, Lillian Hong, Ann O'Connell, Miranda Stewart and Michelle Herring, *Taxation Problems in the Commercialisation of Intellectual Property*, The University of Melbourne, 2006 (also cited as IPRIA Report No. 01/06).
35. Linkage grants are part of the National Competitive Grants Program administered by the Australian Government and are specifically intended to encourage collaborative research with a particular emphasis on linkages with industry.
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37. www.dest.gov.au/sectors/science_innovation/science_agencies_committees/prime_ministers_science_engineering_innovation_council.
38. www.biotechnology.gov.au/index.cfm?event=object.showContent&objectID=53799C64-BCD6-81AC-197045E7DFCC6514.
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40. www.dest.gov.au/sectors/science_innovation/science_agencies_committees/coordination_committee_on_science_and_technology.htm.
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44. As at February 2006: NSW Department of State and Regional Development; Vic Department of Innovation, Industry and Regional Development; Qld Department of State Development, Trade and Innovation; SA Department of Industry, Trade and Regional Development; WA Department of Industry and Resources; Tas Department of Economic Development; ACT Department of Economic Development; NT Department of Business, Economic and Regional Development.
45. Some of these State and Territory schemes are described in The Allen Consulting Group, 2003c, *op. cit.*, pp. 45–6.

46. See The Allen Consulting Group, 2003a, *op. cit.*, for a useful summary of Australian Government policies encouraging R&D in the periods 1983–97 (Chapter 3), and 1998–2003 (Chapter 4).
47. Under the Management and Investment Companies Act, 1983 (Cth).
48. Under the Pooled Development Funds Act 1992 (Cth).
49. Administered by AusIndustry, part of the federal Department of Industry, Tourism and Resources.
50. Such as the Tradex scheme, Space Concession, and Certain Inputs to Manufacture, all administered by AusIndustry.
51. Such as the R&D tax concession, allowing a tax deduction for eligible research expenditure of up to 175%.
52. Such as R&D Start, Pre-Seed Fund, Commercial Ready Program and Biotechnology Innovation Fund.
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54. T. Turpin, 'CRCs and transdisciplinary research: what are the implications for science?', *Prometheus*, 15, 2, 1997, p. 253.
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83. National Principles, *op. cit.*, p. 2.
84. Australian Vice-Chancellors' Committee, the entity representing the interests of all Australian universities: www.avcc.edu.au.
85. Policy Guide, *op. cit.*, p. 5.
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93. www.lesanz.org.au.
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95. www.atse.org.au.
96. www.airg.org.au.
97. For example: www.aussieopportunities.com.
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100. www.bhert.com/default.htm.
101. Reported in KCA News, June 2005, p. 5. Uniseed now includes the commercialisation arm of the University of NSW, New South Innovations. See Uniseed at: http://www.uniseed.com/.
102. www.aigroup.asn.au.
103. www.aeema.asn.au.
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