Business, Industry, and Higher Education Collaboration Council (BIHECC) submission to the Productivity Commission Review of Public Support for Science and Innovation

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Introduction

Quality well supported research and innovation is fundamental to the economic, social and environmental well being of Australia. We must ensure that Australia has the right mix of skills and knowledge, strong industries, a robust and flexible economy, and a culture of innovation. Innovation will be the driving force behind future Australian business prosperity and economic growth. To ensure that Australia is internationally competitive we must increase collaboration and partnerships between education, research, business and government to generate and act on ideas. We must develop a culture of innovation, engendering a broad understanding of the value of education, innovation, research and development. To be a top tier innovator nation Australia needs to have a well resourced world-class research base that will sustain long-term generation of ideas - the lifeblood of innovation. And lastly and most importantly, Australia must maintain its international competitiveness by supporting the translation of ideas and research into economically tradeable products, processes and services.

Executive Summary

The importance of high quality research and efficient knowledge transfer to Australia's future must be recognised. Knowledge transfer takes many forms which are appropriate for different kinds of innovation. The efficiency of knowledge transfer mechanisms often determines the outcomes of the knowledge transfer. Australia should examine ways to expedite high quality knowledge transfer. Increased knowledge transfer will deliver substantial benefits to Australia – knowledge transfer drives research and innovation.

The following are identified as opportunities for improving the efficiency and the effectiveness of the current science and innovation system:

1. Improving support for engagement, knowledge transfer and research commercialisation activities;
2. Expediting the road to market;
3. Developing human capital and culture of entrepreneurialism;
4. Increasing capacity in maths, science, and engineering;
5. Increasing collaboration between business, industry and the higher education sector;
6. Improving incentives for business to invest in knowledge transfer and research and development;
7. Developing intellectual property laws and policies that promote engagement, knowledge transfer and research commercialisation;
8. Improving support for international engagement and networking on commercialisation policy and practice;
9. Developing appropriate benchmarking;
10. Monitoring productivity versus production;
11. Supporting collaboration with publicly funded research agencies (PFRA);
12. Implementation of the Research Quality Framework (RQF); and
13. Improving long term certainty of budget commitment.

Summary of Recommendations

Recommendation 1:
The case for a separate source of public funding to support knowledge transfer and pre-commercialisation activities of universities should be examined in the international context.

Recommendation 2:
Support for:
(a) pre-commercialisation collaboration;
(b) the early stages of commercialisation; and
(c) better incentives for exploiting publicly funded research and development should be examined as ways of increasing collaboration and knowledge transfer and smoothing the road to market.

Recommendation 3:
(a) The government should support the development of programmes that build undergraduate student ties with business and industry and that strengthen the development of employability skills.
(b)Universities should be encouraged to make available programmes designed to enhance researchers' knowledge transfer skills, and to implement policies offering incentives that encourage researchers to pursue knowledge transfer.
(c) Programmes that support institutional capacity building to develop human capital at the knowledge transfer university and business interface should be explored.

Recommendation 4:
(a) Australia should develop programmes to attract more students to maths, science and engineering.
(b) Australia should invest in maths, science and engineering education to ensure that the graduates that come out of Australia's higher education institutions are world class.
This should include investment in up to date infrastructure to provide students and academic staff with current equipment in an advanced and relevant environment.
(c) Universities should be supported to develop students' employability skills and ties with business.
(c) Australia should also support programmes that provide ongoing training and professional development to maths, science and engineering graduates.
(d) Higher Education Contribution Scheme (HECS) incentives could be considered to increase student enrolments in maths, science and engineering.

Recommendation 5: Opportunities for driving engagement, collaboration and knowledge transfer between business and industry and the higher education sector include:
(a) strategically developing the venture capital market which is relatively new and immature, especially at the seed end;
(b) supporting knowledge brokering infrastructure to link up institutions and businesses;
(c) supporting knowledge exchange networks built around collaboration, cooperation and consultation with strong partnerships between industry leaders, technology brokers and knowledge managers;
(d) reducing the risk to small and medium enterprises by providing support for opportunity identification, assessment, negotiation and commercialisation.

Recommendation 6:
(a) Ways of increasing business investment should be examined, including programmes that market the advantages of university collaboration and knowledge transfer to industry and business.
(b) International benchmarks for encouraging business investment should be determined, including economic incentives for business to invest in research.
(c) The current R&D tax concession of 125% should be retained, however, at this stage there is not enough evidence to recommend its expansion.

Recommendation 7:
(a) Australian intellectual property laws should be reviewed to keep abreast of rapid technological development and emerging developments in knowledge transfer.
(b) More uniform national approaches to IP ownership and licensing should be examined.
(c) Public policy development should address the value of intellectual property protection for publicly funded research outcomes versus the value of free rapid dissemination for public good including economic development.

Recommendation 8:
Programmes that support Australian researchers and commercial managers to engage regularly with international commercialisation experts should be developed.

Recommendation 9:
Australia should benchmark its science and innovation system against both existing competitors and emerging competitors to ensure that it is in the top tier of innovator nations.

Recommendation 10:
The Commission's Review should distinguish between increased production, and increased productivity and efficiency in its deliberations on public support for science and innovation, and should identify examples of best practice.

Recommendation 11:
(a) Investment in Australia's publicly funded research agencies to support both world class basic research and strategic research capacity is critical to maintain innovation momentum.
(b) A set of best practice principles should be established for business and university collaboration with Australia's publicly funded research agencies.
(c) The government should consider both mechanisms to enable and incentives to encourage university and business collaboration with publicly funded research agencies.

Recommendation 12:
(a) The likely impact of the Research Quality Framework on Australia's science and innovation system with regard to driving innovation and knowledge transfer should be considered.
(b) Areas of knowledge transfer activity that have been designated as extending outside the scope of the RQF should be considered as part of the Productivity Commission Review of Public Support for Science and Innovation.

Recommendation 13:
Australia should develop a model for public funding of science and innovation which provides more certain longer term funding for research and knowledge transfer.

Part 1. The importance of research and knowledge transfer

The importance of research and knowledge transfer to Australia's future must not be underestimated. Basic research is a critical part of the innovation system. Without basic research limitations of current knowledge prevent us establishing possible avenues for future research and innovation – in reality "we don't know enough to know what we don't know". Basic scientific research reveals new opportunities for applied research and development and leads to innovations that improve peoples' lives.

The process of knowledge transfer - disseminating information and getting feedback - is a fundamental driver of innovation. Knowledge transfer is the process of engaging, for mutual benefit, with business, government or the community to plan, conduct, apply and make accessible existing and new research to enhance material, human, social and environmental wellbeing.[1] Universities and research organisations engage in a number of forms of knowledge transfer:[2]

• Knowledge diffusion	• Generating useful economic and social outcomes via encouraging the broad industry-wide adoption of research findings through communication. • Building capacity within industry through extension, education and training.
• Knowledge production	• Generating useful economic and social outcomes by selling or licensing the results of research in the form of 'commoditised' knowledge. • This is a 'standard' model of intellectual property management and research commercialisation.
• Knowledge relationships	• Generating useful economic outcomes by providing services that indirectly exploit broad intellectual property (IP) platforms consisting of trade secrets, know-how and other forms of tacit knowledge. • This approach centres on knowledge networks, cooperation, collaboration, joint ventures and partnerships.
• Knowledge engagement	• Generating useful economic outcomes as a by-product of shared interests and concerns that transcend the boundaries of the university per se.

There is an ongoing international debate regarding the protection or 'propertisation' of intellectual property (IP) versus the free dissemination of knowledge for public good.

Protection and sale of IP can be seen as an opportunity for knowledge to be adopted and applied by business in the creation of wealth, and for universities and research organisations to retain and build their place in the increasingly distributed system of knowledge production—and earn income in the process. Others see 'propertisation' as an 'enclosure of the knowledge commons' where 'huge swathes of knowledge are fenced off into privately owned plots'[3]

Protection of IP results in clear IP ownership which enables knowledge creators, particularly in the public sector, to have a continued right of access to their discoveries and to ensure open and widespread access to users through non-exclusive licensing arrangements for national economic and industry benefit. For example, widespread adoption of new knowledge in the form of improved production processes has been an important aspect of building and retaining international competitiveness in Australian agriculture and mining. Universities and publicly

[1] PhillipsKPA. 2006, *Knowledge Transfer and Australian Universities and Publicly Funded Research Agencies.* Canberra: Department of Education, Science and Training.
[2] Howard, J. 2005, *The Emerging Business of Knowledge Transfer*. Canberra: Department of Education, Science and Training.
[3] Bollier, D. 2002, *Silent Theft: The Private Plunder of Our Common Wealth*. Routledge.

funded research organisations have had an ongoing lead role in the creation, dissemination and the promotion of adoption of discoveries and inventions in this sector.[4]

Protection of IP also allows the creators of knowledge to secure and award exclusive access rights to knowledge products through licensing agreements. Exclusive access tends to be sought where the IP provides the foundation for a new marketable product or a new business. In the pharmaceutical industry, where development is long, expensive, risky and heavily regulated, it is argued that companies need an exclusive right (through patents) to recoup these development costs.

Many universities perceive their raison d'etre to be the generation and dissemination of knowledge for the benefit of society as a whole; viewing knowledge as a public good, and subscribing to the scientific tradition of fully and promptly making public all research findings so that others may build upon them. This free sharing of intellectual property is often viewed as a fundamental driver of research.

The open source movement is a current example of the free dissemination of knowledge for public good. Increasingly, companies are adopting an 'open source' licensing that implicitly recognises that unused intellectual property has no value explicitly and is available for sharing under standardised forms of collaborative research agreements. Collaborators can then concentrate on creating value through building sustainable business propositions and a bigger market. This approach is becoming increasingly important in some sectors, for example, companies such as IBM have an active licensing program.

These different modalities all play different, but equally important roles in the knowledge transfer spectrum. Collectively these approaches provide benefits which range from sector wide benefits through the free sharing of knowledge to private good from a business perspective. Unused intellectual property has little value - the mechanism of transfer is critical to successful innovation.

Public policy development should address the value of Intellectual Property protection for publicly funded research outcomes versus the value of free rapid dissemination for public good including economic development.

The importance of high quality research and efficient knowledge transfer to Australia's future must be recognised. Knowledge transfer takes many forms which are appropriate for different kinds of innovation. The efficiency of knowledge transfer mechanisms often determines the outcomes of the knowledge transfer. Australia should examine ways to expedite high quality knowledge transfer. Increased knowledge transfer will deliver substantial benefits to Australia – knowledge transfer drives research and innovation.

[4] Howard, J. 2005, The *Emerging Business of Knowledge Transfer*. Canberra: Department of Education, Science and Training.

Part 2. What are the economic, social and environmental impacts of the science and innovation system?

Economic

Innovation is essential to the Australian economy. Without innovation there is no capital deepening – innovation drives the expansion of the economy and increases productivity per worker. However, the direct economic correlation between research input and economic output is very difficult to establish. In particular identifying the value add of research input can be quite difficult – for example - what was the value of Henry Ford's research into the internal combustion engine for the company compared to its value to the economy? Quantifying the exact relationship between the two is of limited value. It is more important to understand the broader impacts of science and innovation which include:

- Improved national economic performance, in terms of increased national output (GDP), employment and exports that flow directly from businesses sharing, exchanging and more effectively using knowledge that flows from involvement in network arrangements;
- Improved industry competitiveness, at an international level, where there is broad adoption and application of new knowledge generated through knowledge networks arrangements;
- Improved business performance for business and industry which successfully innovate on the basis of knowledge transfer, which in turn results in spill-overs to industry more widely;
- Community wide gains through greater productivity, higher incomes, greater exports; and
- The innovation system is an engine whose research operations are an important stimulus, creating new companies, new jobs and attracting money regionally and nationally.

The British Government has recognised the importance of innovation (the successful exploitation of new ideas) and rightly asserted that, to thrive in the competitive global economy, successful nations will be those that can "compete on high technology and intellectual strength, attracting the highest-skilled people and the companies which have the potential to innovate and to turn innovation into commercial opportunity."[5]

Economic benefit can also be indirect or hard to quantify:

- Research in preventative medicine, for example, may produce no direct or large commercial benefits, yet it can result in a healthier population and thus a more productive workforce and a reduction in both private and public expenditure on health. Impacts resulting from science and innovation can thus include better health, and amelioration of social and environmental problems;
- Highly skilled graduates are critical to our economy. At the Inaugural Ericsson Innovation Awards held in Canberra in February 2001, Luis Mejia, Head of Commercialisation at Stanford University, made the point that :

  "While the transfer of technology takes many forms, the most common form is the education and technical know-how that students take with them when they graduate. That

[5] HM Treasury, Department of Trade and Industry and Department for Education and Skills. 2005, *Science and Innovation Investment Framework 2004–2014.* United Kingdom.

form is often overlooked in discussions on Silicon Valley and start-ups. But, it is the one that probably has the greatest fiscal and social impact on the broader economy."

"In fact, Gordon Moore, Co-Founder of Fairchild Semiconductor and Intel believes that Stanford's major contribution to Silicon Valley has been the several hundred graduating Master's degree students that each year add to the Silicon Valley engineering talent pool." [6]

Any analysis of 'Public Support for Science and Innovation' has to consider the importance of investment in quality education and whether the current education framework sufficiently supports the science and innovation system. In particular, support for science, technology and engineering skills development is critical.

Improving research and development performance

- Australia's expenditure on research and development is roughly 25% lower than top OECD countries. There is a particularly low industry investment in research and development in Australia – less than 16 %. Advanced economies have 40-50%. Australia's investment in 'knowledge' is roughly 4.1% of GDP, below the OECD average of 5.2%.[7]
- Historically Australia has never been a big manufacturing nation, and Australia's industries are not research intensive. Roughly eighty percent of Australian research and development is conducted in universities.
- Given the lack of low cost labour in Australia it is critical that we maintain our competitiveness through innovation. To do this we must examine the effectiveness of Australian knowledge transfer systems. The way that knowledge transfer is conducted is just as important as whether it is undertaken at all.
- In order to maintain market edge and to enhance Australia's competitive advantage Australia should focus research and development in areas where we have comparative advantages – for example Australia is very strong in health and medical research and development.
- A recent report by the Allen Consulting Group for the Australian Vice Chancellor's Committee and Business Council of Australia estimates that the $83m that was made by Australian universities through licensing revenues in 2000 could have been doubled if 'best practice' had been followed.[8] The 'best practice' model includes free flow of information through knowledge exchange networks.
- The Allen Consulting Group also estimated that companies formed on the basis of commercialising publicly funded research had sales of between $2 billion and $3 billion. While this estimate is highly speculative, it does suggest that there is potential for substantial economic benefit if the level of commercialisation can be increased through improved knowledge exchange. The Australian wine industry, which has developed and grown through networking and collaboration in production technologies, now exports almost a third of total production compared to two percent in the mid 1980. Whilst the contribution of improved knowledge transfer to GDP cannot be assessed with any accuracy due to the limitations of modelling techniques, proxy indicators such as increased sales, employment, investment and exports are widely accepted indicators of economic impact.

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[6] Mejia L.R. 2001, *Innovation – Observations from Stanford University*, Inaugural Ericsson Innovation Awards.
[7] Productivity Commission. 2006, *Issues Paper – Public Support for Science and Innovation*. Canberra.
[8] Allen Consulting Group. 2004, *Building Effective Systems for the Commercialisation of University Research.* Canberra: Australian Vice Chancellor's Committee and Business Council of Australia.

- As part of supporting Australia's economic development through innovative technologies, thought needs to be given to negative effects of the current system, such as managing impacts on competition, duplicated activities, opportunity loss and crowding out of private research and development, and unnecessary administrative and compliance costs.[9]

Social

The science and innovation system has profound social impacts, including those that may not be easily economically quantifiable. These impacts include:

- National capacity building and development of human capital. The science and innovation system is a generator of skilled labour, with graduates being a major point of knowledge transfer into the community nationally;
- Injection of funds into regional economies, providing employment and socioeconomic stability for communities;
- Major social impacts on communication and the accessibility of information– for example mobile phone technology or the internet;
- Informing educational development. Science and innovation translate to all levels of learning, teaching and the development of excellence;
- Science and innovation stimulates community engagement, knowledge transfer and enrichment – for example through generating community outreach programmes ;
- Development of cultural capital. Experts in science and innovation are a cultural resource, and often contribute to public intellectual life through social comment, presentations to business and community groups and involvement in government and professional association committees;
- Bridging social divisions. Technological innovation and development can reduce or ameliorate equity issues – for example information technology (including the internet) has had a major effect on the provision of services for disabled people and rural communities; and
- The application of appropriate research may also result in reduced expenditure and better outcomes in welfare, incarceration and remedial learning. By achieving a healthier, better educated and more employable population, such activities have the potential to produce tangible, and measurable economic, as well as social benefits.

Environmental

Innovation is critical for sustainable development in Australia. In improving innovation capacities and effectiveness, and in encouraging economic growth and competitiveness, Australia also needs to consider the environmental implications of technologies, processes and innovations.

- The environmental impact and benefits of innovation should be considered at all stages - planning, development, implementation and review;
- Innovation is important for dealing effectively and efficiently with environmental problems and for better managing our environment; and
- Innovation that is environmentally sound is not a constraint on economic growth. Rather, sustainable development should be seen as economic development that takes into account environmental consequences and also contributes to social benefits (the 'triple bottom line') and is vitally important in protecting the environment on which industry, innovation, technological advances and economic growth depend.

[9] Department of Education, Science, and Training. 2005, *Knowledge Exchange Networks in Australia's Innovation System – Overview and Strategic Analysis.* Canberra.

Part 3. What are the impediments to the effective functioning of Australia's innovation system?

1. Support for engagement, knowledge transfer and research commercialisation activities

Current public funding to Australian universities is targeted at supporting their traditional activities of teaching, learning, research and research training. They do not currently receive dedicated funding to support engagement, knowledge transfer and research commercialisation activities. (Some universities access limited support for specific knowledge transfer activities through programmes such as CRCs, ARC Linkage Grants, and industry programmes such as the Preseed fund.) Some of the public funding that they receive specifically excludes commercial use. This means that funding for engagement, knowledge transfer, and research commercialisation activities is usually drawn from discretionary revenues and weighed against other spending priorities.

While some funding targeted at research commercialisation is available under the Commonwealth's Commercial Ready Program, the focus of this scheme is on assisting the private sector. Most universities and their commercial arms are not eligible for assistance under the Commercial Ready Program.

Current commercialisation performance indicators suggest that in some areas the performance of Australian universities is falling behind that of universities in the United Kingdom, Canada and the United States.[10,11]

Engagement and knowledge transfer are integrated with fundamental academic activities– research, scholarship, learning, and teaching, but they require additional capabilities, resources, infrastructure and relationships that extend beyond the traditional academic domains of scholarship, learning, and teaching. Establishing a separate source of public funding to support the engagement, knowledge transfer, and pre-commercialisation activities of universities would enable Australia to remain internationally competitive. Funding for knowledge transfer should not be at the expense of teaching or research, but should represent additional funding.

International initiatives, such as those undertaken in the United Kingdom, should inform public policy development in Australia. The United Kingdom's main 'third-stream' funding scheme, the Higher Education Innovation Fund provides approximately £75 million annually for universities to build their capacities for engagement and knowledge transfer.[12]

The House of Representatives Standing Committee on Science and Innovation, in its report on *Pathways to Technological Innovation*, recently recommended that the Business, Industry, and Higher Education Collaboration Council develop a business case for third stream funding. Minister Bishop has requested that the council implement the recommendation by developing a business case for knowledge transfer.

Recommendation 1

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[10] PhillipsKPA. 2006, *Knowledge Transfer and Australian Universities and Publicly Funded Research Agencies.* Canberra: Department of Education, Science and Training.
[11] Davis, G & Tunny, G. 2006, *International Comparisons of Research and Development*, Canberra: The Treasury. http//www.treasury.gov.au/.
[12] http://www.hefce.ac.uk/reachout/heif/

The case for a separate source of public funding to support knowledge transfer and pre-commercialisation activities of universities should be examined in the international context.

2. The road to market

Generally the research commercialisation process is time consuming and costly. It can take ten to fifteen years or more to get a new discovery to the stage where it produces commercial returns. In some disciplines, such as the pharmaceutical field where clinical trials and other regulatory requirements are mandatory, the length of time between discovery and commercial return can be particularly prohibitive. For every successful outcome there are many failures. It is therefore critical that policy and funding settings for promoting engagement, knowledge transfer and research commercialisation take a long-term view.

Profitable research commercialisation ventures are few and far between. Effective commercialisation of research, therefore, depends on the existence of a large portfolio of research, coupled with adequately resourced and sufficiently skilled commercial operations. Many smaller Australian universities do not have the critical mass of research upon which to base a successful commercial operation, and many small firms are less able to compete in export markets; as a result examples of collaboration between multiple institutions and business to build critical mass and share expertise are increasing. (Examples include UniQuest and the Australian Institute for Commercialisation.)

Australia's research capacity is world class. Where it performs less well is in the process of converting its excellent research into social and economic capital, new businesses and new jobs. Measures needed to develop an enabling culture and to further encourage multi-institution collaboration could include offering specific funds for pre-commercialisation collaboration, the early stages of commercialisation and better incentives for exploiting publicly funded research and development.

Recommendation 2
Support for (a) pre-commercialisation collaboration, (b) the early stages of commercialisation, and (c) better incentives for exploiting publicly funded research and development should be examined as ways of increasing collaboration and knowledge transfer and smoothing the road to market.

3. Human capital and culture of entrepreneurialism

In 2003 the Mapping Australian Science and Innovation report identified that the "availability of innovation skills and cultural attitudes limit Australia's innovation potential."[13] There is an increasing awareness within the Australian higher education community of the importance of human capital and entrepreneurship to technological innovation and knowledge transfer. There are several points where human capital development is critical.

The first significant opportunity to increase Australia's human capital is investment in quality education to generate highly skilled graduates. In particular, it is critical for Australia to invest in maths, science and engineering education to build skills at a national level. As part of this the

[13] Department of Education, Science, and Training. 2003, *Mapping Australian Science and Innovation*. Canberra.

Government should invest in the development of programmes that offer quality academic content, integrated development of innovation skills, build ties with business and industry and that strengthen the development of graduate's employability skills.

The second critical point is investment in skill development of academic and general staff in universities. The great majority of university researchers are keenly interested in seeing their research reach its full potential. Researchers face many demands on their time ranging from lecturing, supervising students, managing projects, administrative duties, knowledge transfer through publications and presentations and applying for funding to support their research activities. Researchers may lack sufficient entrepreneurial skills take new ideas to market, such as market knowledge and the ability to recognise the right opportunity. Often, although keen to pursue knowledge transfer, they encounter problems in engagement that confound the process. The Audit of Science, Engineering and Technology Skills report noted that it is "important to enhance science, engineering and technology worker's entrepreneurial skills to better facilitate knowledge transfer and development of commercial applications of Australian research and development."[14]

Supporting the development of a culture of engagement and removing inhibitors of engagement is a critical part of improving Australia's innovation performance. Universities should be encouraged and supported to make available programmes designed to enhance researchers' knowledge transfer skills, and to implement policies offering incentives that encourage researchers to pursue knowledge transfer.

One of the key issues in building engagement, knowledge transfer and research commercialisation is facilitation. The key driver is human capital. Funding for engagement, knowledge transfer, and research commercialisation should be provided for two main purposes:

- Institutional capacity building to develop human capital at the knowledge transfer university and business interface. Such arrangements would better support industry, university and community needs.
- Specific projects and initiatives – to support one-off ventures and activities that address a specific need and opportunity and have an identifiable and measurable outcome.

Commercialising research is a complicated and demanding process, which requires highly skilled staff with strong commercial backgrounds. Skilled commercial managers are highly sought after internationally and are expensive to both attract and keep. Unless sufficiently resourced, university knowledge transfer and commercialisation offices will struggle to employ the calibre of staff required to deliver on the commercial potential of their portfolios.[15] The talent pool available in Australia is relatively small so policies that make it easier to attract top talent from overseas are desirable.

Just as it takes time for individual discoveries or inventions to deliver results, it takes time for research transfer and commercialisation offices to build up expertise, expand their patent portfolios, develop links with the financial markets and industry and manage projects through the commercialisation process. Supporting universities through this process will streamline the path to market in Australia. Support for capacity building at the institutional level and at the national

[14] Department of Education, Science, and Training. 2006, *Audit of Science, Engineering and Technology Skills*. Canberra.

[15] Yenken, J., Ralston, L. and Department of Education, Science and Training. 2005, *Evaluation of Incentive for Commercialisation of Research in Australian Universities.* Canberra: Department of Education, Science and Training.

level is critical to foster a culture of innovation and knowledge transfer.

Recommendation 3
(a) The government should support the development of programmes that build undergraduate student ties with business and industry and that strengthen the development of employability skills;
(b) Universities should be encouraged to make available programmes designed to enhance researchers' knowledge transfer skills, and to implement policies offering incentives that encourage researchers to pursue knowledge transfer; and
(c) Programmes that support institutional capacity building to develop human capital at the knowledge transfer university and business interface should be explored.

4. Capacity in maths, science, and engineering.

The long term sustainability of Australia's skills base in the enabling sciences is under pressure. Australia is on the brink of a severe skills shortage in professions that require maths, science, and engineering.[16, 17] Industry views indicate that there are specific, immediate and long term supply issues that must be addressed.[18] These disciplines are critical if Australia is to be a top tier innovator nation. The skills that maths, science, and engineering graduates possess are critical for knowledge transfer, innovation and development. Without skilled people in these areas we can not convert ideas into innovations.

Developing breadth and depth of human capital in maths, science and engineering is critical for Australia's capacity expansion. Without these skills, not only can we not innovate successfully, but we can not use other nations' knowledge productively. The top ranking innovation nations do not disseminate cutting edge intellectual property, knowledge or their most innovative products freely. Often only less innovative products are freely distributed to the international market. Building capacity in maths, science, and engineering will allow Australia to use capital goods more productively. While the rest of the world is a significant source of ideas and technology, Australia can not rely on a strategy of passive absorption to maintain strong productivity performance. In order to benefit from externally developed innovations, Australia needs to have well trained scientists, a technologically capable workforce and active engagement in forward-looking research.

Investment in primary and high school science education, and in training and retaining high quality science teachers is an important part of long term capacity building.[19] It appears that the quality of science, engineering and technology teaching in schools may act as a limiting factor in the long term capacity to graduate students suitably qualified to meet the high expectations of industry.[20] Quality high school maths and science teaching has a critical flow on effect on student's choices and success at university. Investment in world class higher education courses in the enabling sciences is also critical to recruiting and retaining students.

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[16] Department of Education, Science, and Training. 2003, *Mapping Australian Science and Innovation*. Canberra.
[17] Department of Employment and Workplace Relations. 2005, *Workforce Tomorrow*. Canberra.
[18] Department of Education, Science, and Training. 2006, *Audit of Science, Engineering and Technology Skills*. Canberra.
[19] Australian Council of Deans of Science. 2005, *Who's teaching Science? Meeting demands for qualified science teachers in Australian secondary schools*. http://www.acds.edu.au/
[20] Department of Education, Science and Training. 2006, *Audit of Science, Engineering and Technology Skills*. Canberra.

Currently many universities are working with run down, out of date and obsolete scientific equipment and infrastructure. The *Mapping Australian Science and Innovation* report reached the conclusion that Australia's research infrastructure is under significant pressure.[21] It is critical that a significant investment is made in scientific infrastructure to ensure that students and researchers have access to up to date internationally competitive facilities. Without these resources there is a danger that that graduates will not be adequately prepared for the work environment, that limits of infrastructure will reduce opportunities for innovation and technology transfer, and that loss of intellectual capacity to overseas institutions will increase. The recently released Audit of Science, Engineering and Technology (SET) Skills report identifies "ensuring quality infrastructure is in place to support SET training and research" as a key part of ensuring that Australia has the skill sets to facilitate continued development of knowledge intensive industries.[22] The audit report reinforces the notion that "research and innovation springs from world-class facilities, well resourced to support a critical mass of high quality researchers."[23]

The Higher Education Contribution Scheme (HECS) as currently formulated appears to result in adverse selections against the national priorities for innovation. Anecdotal evidence suggests that the current system may act as a disincentive for people to study science, maths and engineering, and may encourage universities to offer degrees which have lower marginal costs such as Arts and Asian studies. Anecdotally, some students have indicated that the cost of their course is a major factor in deciding what course to take - the relatively high cost of a degree in maths, science and engineering, coupled with relatively poor pay and high level of uncertainty of employment in many scientific disciplines may act as a disincentive for students (Table 1). One way of increasing Australia's capacity in maths, science and engineering would be to provide an incentive for students to study priority disciplines – such as significantly reducing the HECS costs to students.

Table 1. Example of relative HECS costs for different degrees.[24]

Degree	Approximate HECS cost to student generated using 2006 ANU unit costs.	Approximate HECS cost to student generated using 2006 University of Melbourne unit costs.
Bachelor of Engineering/ Bachelor of Commerce	$33,456	$33,895
Batchelor of Laws	$32,640	$32,016
Bachelor of Engineering/ Bachelor of Science	$27,880	$27,348
Bachelor of Engineering	$22, 304	$27,348
Batchelor of Science	$18,728	$20,511
Batchelor of Commerce	$16,728	$20, 511
Bachelor of Arts Political Science	$11,760	$14,400
Bachelor of Asian Studies	$11,760	$14,400

Recommendation 4

(a) Australia should develop programmes to attract more students to maths, science and engineering.

(b) Australia should invest in maths, science and engineering education to ensure that the

[21] Department of Education, Science, and Training. 2003, *Mapping Australian Science and Innovation*. Canberra.

[22] Department of Education, Science, and Training. 2006, *Audit of Science, Engineering and Technology Skills*. Canberra.

[23] Department of Education, Science, and Training. 2006, *Audit of Science, Engineering and Technology Skills*. Canberra.

[24] NB. These costs can vary considerably across universities.

graduates that come out of Australia's higher education institutions are world class. This should include investment in up to date infrastructure to provide students and academic staff with current equipment in an advanced and relevant environment.
(c) Universities should be supported to develop students' employability skills and ties with business.
(d) Australia should also support programmes that provide ongoing training and professional development to maths, science and engineering graduates.
(e) The Higher Education Contribution Scheme (HECS) incentives could be considered to increase student enrolments in maths, science and engineering.

5. Collaboration between business, industry and the higher education sector

Improving links with business and industry remain ongoing priorities for the Business, Industry and Higher Education Collaboration Council (BIHECC). BIHECC recently commissioned a report into *Knowledge Exchange Networks in Australia's Innovation System* which outlines the networks and organisations that exist in Australia for the exchange and diffusion of knowledge from universities and research institutions to the wider community. The report identifies a number of challenges for Australia's innovation system.

There are number of technology transfer challenges facing business and industry, not the least of which is the difficulty of identifying researchers and institutions with the skills and intellectual property that could contribute to sound business outcomes. Engagement is particularly difficult for small and medium enterprises (SMEs). Roughly 34 per cent of Australian SMEs use new technologies to improve their business or develop new products compared with 85 per cent of their European and US counterparts.[25] Two key reasons why Australian SMEs do not traditionally adopt new technologies are:

- They are not always aware of the latest developments in the research and development (R&D) sector; and
- Assessing and adopting new technologies can be a risky and resource consuming process.

Businesses and particularly SMEs often have major difficulties in accessing the research capacities and capabilities of universities and publicly funded research organisations. Small to medium enterprises encounter a different set of problems compared to large corporations. These include:

- the level of linkages between research and industry;
- lack of experienced and skilled people in knowledge transfer and commercialisation;
- research culture perception of commercial activity;
- availability of venture capital - the venture capital market is relatively new and immature, especially at the seed end;
- knowledge and awareness; and
- issues of management and clear ownership of intellectual property.

There are many other reasons why universities and research organisations find it relatively difficult to engage with SMEs. These can include a preference by SMEs to develop their own technologies and to acquire knowledge through less formal relationships, including graduate recruitment.

[25] Department of Education, Science, and Training. 2003, *Mapping Australian Science and Innovation*. Canberra.

In today's globalised economy, SMEs are facing ever increasing competitive pressures. They need to gain new market information and knowledge to remain competitive. An increasingly common strategy is to develop clusters of networks with other SMEs. Clustering enables the development of informal social networks through which knowledge can flow and be used. A recent, successful approach is that of knowledge exchange organisations that can guide SMEs through the large amount of information in the market about technologies, innovation capabilities and research outcomes. In addition, they educate and train researchers and research organisations in commercialisation processes and business development skills.

BIHECC would strongly support programmes designed to further improve engagement between universities and business - particularly small and medium enterprises which are typically the drivers of economic growth in the Australian economy. Commonly, Australian research organisations use a 'technology push' approach to commercialisation, and one of the frequently cited reasons for low research and development in Australia is the lack of a market pull. Supporting business and industry to develop a 'demand-pull' environment would enhance knowledge transfer in Australia. Increased collaboration between business, industry and the higher education sector is critical for developing cross sectoral understanding, including developing the higher education sector's awareness of industry drivers and needs. Industry bodies have the ability to play a key role in brokering and developing ongoing relationships and knowledge exchange networks with institutions which will expedite knowledge exchange from universities to business and industry.

Recommendation 5

Opportunities for driving engagement, collaboration and knowledge transfer between business and industry and the higher education sector include:

(a) strategically developing the venture capital market which is relatively new and immature, especially at the seed end;

(b) supporting knowledge brokering infrastructure to link up institutions and businesses;

(c) supporting knowledge exchange networks built around collaboration, cooperation and consultation with strong partnerships between industry leaders, technology brokers and knowledge managers;

(d) reducing the risk to small and medium enterprises – the cost of identifying assessing and accessing new opportunities in the research sector can be expensive. The development of a programme to help small and medium enterprises with opportunity identification, assessment, negotiation and commercialisation planning could encourage small and medium enterprises to look to the research sector as a catalyst for innovation and growth.

6. Incentives for business to invest in knowledge transfer and research and development.

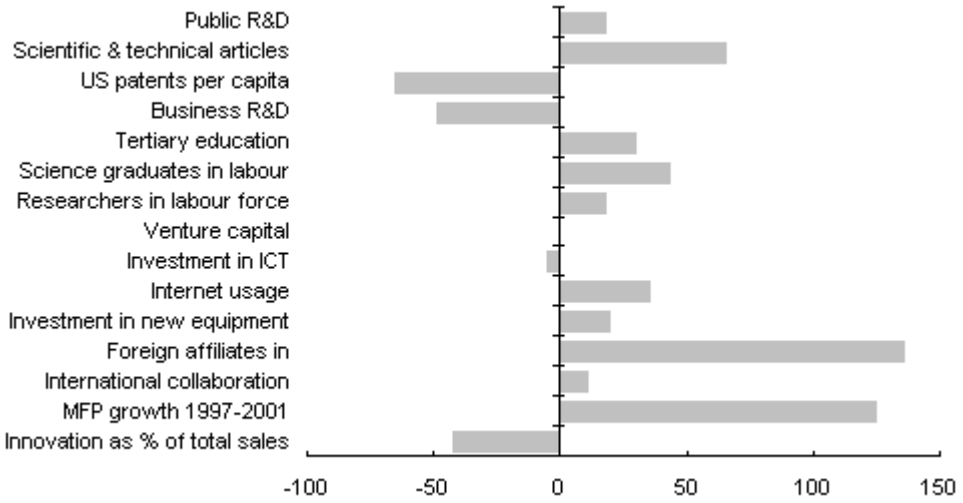
As outlined in the 2003 House of Representatives report, *Riding the Innovation Wave: the Case for Increasing Business Investment in Research and Development*, the level of business investment in research and development in Australia remains significantly below the OECD average. In most other OECD countries business investment represents a greater proportion of overall investment in research and development than in Australia and has been growing at a faster rate. Australian investment in research and development is about 1.6 percent of GDP, with business expenditure on research and development at approximately 0.8 percent of GDP.

Australia should develop a national innovation strategy encompassing total funding available for research and development from public and private sources, and increased public support for Australia's core research capacity. As part of this strategy the Government should consider

setting a target of national investment in research and innovation from all sources at 2 percent of GDP by 2010 and 3 percent by 2020. This would keep Australia apace with global competitors such as China, which has set a target of increasing research and development to 2.5 percent of GDP by 2020, and the EU and Canada which have recently committed to spending to 3 percent of GDP by 2010 to compete with similar levels in Sweden, the United States and Japan.[26]

Australia's innovation performance compared with OECD average (Figure 1) shows that Australia is falling significantly behind the OECD average in business research and development.[27]

Figure 1. Australia's innovation performance compared with OECD average (percentage difference).



The percentage of business expenditure in research and development (BERD) performed in high-technology manufacturing industries is significantly lower in Australia (21%) than in top tier innovator nations such as United states (39%), Japan (43%), United Kingdom (49%),Canada (51%), Sweden (52.5%) and Finland (57%).[28] In order to develop Australia as a first tier innovator nation we need to increase Australian business investment to similar levels.

Programmes that stimulate research and development through tax concession have only been moderately successful to date at driving research and development investment. What they have not managed to change is the fundamental value add. Some research and development incentives in the tax system are appropriate to keep enterprises focused as a key part of the value chain. Generally these tax incentives are not the most important element in determining if a company engages in research and development, and as such are not a major driver of innovation. The current tax concession should be retained as a small but significant incentive. Although beneficial, at this stage there is not enough evidence to support an argument to increase the current research and development tax deduction of 125%. Economic incentives for industry and

[26] Davis, G & Tunny, G. 2006, *International Comparisons of Research and Development*, Canberra: The Treasury. http//www.treasury.gov.au/.

[27] Department of Education, Science, and Training. 2005, *Innovation Report 2004-05 Backing Australia's Ability – Real Results Real Jobs.*

[28] Percentage of BERD performed in high-technology manufacturing industries – by OECD country, 2003. Department of Education Science, and Training, based on ABS Research and Development data and OECD MSTI database.

business to invest in research and development are provided by all leading research and development nations.[29]

Policies that encourage and provide incentives for greater business and industry sector investment in research and development will have positive flow-on effects for commercially focused research and development in Australian universities. Policies that support research and development will enhance collaboration and linkages between the sectors. A key part of the development of Australia's science and innovation system is the promotion of the advantages of university led research to business and industry, and to develop a culture of collaboration.

A culture shift is required if Australia is to become a top tier innovator. There are a number of ways in which business can gain competitive advantage from working with universities:

- Access to new ideas of all kinds;
- The ability to achieve excellence across a wider range of disciplines and through a much larger intellectual gene pool than an individual business could hope to create on its own;
- The ability to leverage the research dollar;
- A chance to spot and recruit the brightest young talent;
- The ability to expand pre-competitive research – spreading risk and widening research horizons; and
- Access to specialised consultancy.[30]

Developing both business and university understanding of the benefits of collaboration is critical to driving this culture shift.

Recommendation 6

(a) Ways of increasing business investment should be examined. These could include programmes that market the advantages of university collaboration and knowledge transfer to industry and business.

(b) International benchmarks for encouraging business investment should be determined, including economic incentives for business to invest in research.

(c) The current R&D tax concession of 125% should be retained, however, at this stage there is not enough evidence to recommend its expansion.

7. Intellectual property laws and policies that promote engagement, knowledge transfer and research commercialisation

Management of intellectual property (IP) is a critical part of successful knowledge transfer and research commercialisation. There is an ongoing international debate regarding the protection or 'propertisation' of intellectual property versus the free dissemination of knowledge for public good. It is critical that Australian IP laws that are able to deal appropriately with emerging developments in knowledge transfer. It is important to review Australian IP laws to keep abreast of rapid technological development. Australian IP laws and policies need to promote engagement, knowledge transfer and research commercialisation and to clearly outline what level of experimentation and development can be conducted on and around new intellectual property without infringing on protected rights.

The Australian Research Council has defined a set of *National Principles of IP Management* for publicly funded research, however many different models of IP management are being applied

[29] Lambert, R. 2003, *Lambert Review of Business-University Collaboration*. UK: HM Treasury.
[30] Lambert, R. 2003, *Lambert Review of Business-University Collaboration.* UK: HM Treasury.

by Australian research organisations with varying results. There may be value in developing more uniform national approaches to IP ownership, transactions and licensing to encourage greater technology diffusion.

It is obvious that this is an area that is evolving rapidly and needs continued work. Future public policy development should address the issue of IP protection for publicly funded research outcomes versus the need for rapid free dissemination of knowledge for public good and identify principles of best practice.

Recommendation 7
(a) Australian intellectual property laws should be reviewed to keep abreast of rapid technological development and emerging developments in knowledge transfer.
(b) More uniform national approaches to IP ownership and licensing should be examined.
(c) Public policy development should address the value of intellectual property protection for publicly funded research outcomes versus the value of free rapid dissemination for public good including economic development.

8. Support for international engagement and networking on commercialisation policy and practice

Publicly funded research organisations in developed countries around the world are grappling with the same challenges in knowledge transfer and commercialising the outcomes of their research as those in Australia.

Recommendation 8
Programmes that support Australian researchers and commercial managers to engage regularly with international commercialisation experts should be developed.

9. Benchmarking

The challenge for the Australian innovation system is whether to benchmark against comparable countries, e.g. Canada; existing competitors, for example USA; or emerging major competitors including a number of Asian nations. A forward looking country should look to emerging competitors when developing benchmarks, as well as to current top tier nations.

Recommendation 9
Australia should benchmark its science and innovation system against both existing competitors and emerging competitors to ensure that it is in the top tier of innovator nations.

10. Productivity versus production

It is important for the commission to distinguish between increased production and increased productivity and efficiency in its deliberations on public support for science and innovation. This issue goes to the heart of how well public funds (and business investment) are utilised; do the funds produce more at a lower marginal cost or investment or just more? Is the quality produced competitive?

Recommendation 10

The commission's review should distinguish between increased production and increased productivity and efficiency in its deliberations on public support for science and innovation, and should identify examples of best practice.

11. Collaboration with publicly funded research agencies (PFRA)

In recent times the environment in which publicly funded research agencies operate has been undergoing a paradigm shift. The 2004 review of collaboration between universities and major publicly funded research agencies identified a number of barriers to collaboration.[31] In response to this review, and to the changes to their external operating environment, publicly funded research agencies have had to re-examine the way that they engage with other organisations and how they undertake knowledge transfer.

For example, the Commonwealth Science and Industrial Research Organisation (CSIRO) has undergone a massive change programme over the last four years which is only now delivering results. CSIRO initiatives such as the new Science Investment Process, which is specifically designed to avoid a mismatch between the research environment and market, and the Flagship programme, which is aimed at supporting engagement and collaboration, have resulted in major cultural change and an organisation with greater collaborative capacity. The impact of these changes have not yet been fully realised, and sufficient time needs to be allowed to fully establish their impact on developing and supporting ongoing partnerships with other research focused institutions, and enhancing knowledge transfer and innovation.

In order to move Australia to first tier innovator status, the efforts of publicly funded research agencies to engage with collaborators and conduct knowledge transfer need to be supported. In particular their efforts to minimise opportunity costs, to remove prohibitive administrative burdens, and to minimise financial barriers should be encouraged. Examples of best practice should be identified to support innovative approaches and to encourage continuous improvement in the sector. In addition, mechanisms to enable and incentives to encourage university and business collaboration with publicly funded research agencies should be considered.

It is important to understand that basic research underpins breakthrough science and innovation, and that commercialisation can not be successful without strong support for basic research. Investment in Australia's publicly funded research agencies to support both world class basic research and strategic research capacity is critical for the long term development of Australia as an innovative nation.

Recommendation 11
(a) Investment in Australia's publicly funded research agencies to support both world class basic research and strategic research capacity is critical to maintain innovation momentum.
(b) A set of best practice principles should be established for business and university collaboration with Australia's publicly funded research agencies.
(c) The government should consider both mechanisms to enable and incentives to encourage university and business collaboration with publicly funded research agencies.

12. Research Quality Framework (RQF)

[31] Department of Education, Science, and Training. 2004, *Review of closer collaboration between universities and major publicly funded research agencies.* Canberra.

Currently there is no systemic and expert review based way to measure the quality and impact of research conducted in universities and publicly funded research agencies and its benefits to research and the wider community. For example, the existing distribution of university research block funding is based on inadequate proxy measures of quality, eg numbers of publications, external research income and student completions. Clearly the currently used quantity-based measures do not satisfactorily assess the quality or impact of research undertaken in the university sector.

The stated objective of the RQF is to develop a broad assessment mechanism of research quality and impact that will be relevant across the full breadth of research organisations in receipt of public funding. What effect this will have on the higher education sector with regard to driving innovation and knowledge transfer is not yet apparent. To enhance Australia's innovation system the RQF needs to recognise and reward high quality and high impact research wherever and whenever it occurs.

The Research Quality Framework Expert Advisory Group has acknowledged that the following issues in relation to "knowledge transfer" require consideration outside the context of the RQF:

- current "knowledge transfer" activities, how they are funded and how they fit with other funding mechanisms and frameworks;
- how current "knowledge transfer" activities may be strengthened and supported without distorting the normal working of the market; and
- the potential additional return on investment over and above what is already in place.

Although some of these areas of knowledge transfer activity have been designated as extending outside the scope of the RQF they are an important outcome of public support for science and innovation, and it is important that they are considered carefully as Australia positions itself for the future. Areas of best practice should be identified and rewarded.

The Business, Industry, and Higher Education Collaboration Council has been tasked by the Minister and the House of Representatives Standing Committee on Science and Innovation in its report on Pathways to Technological Innovation with developing a business case for third stream funding. As part of its review the Business, Industry, and Higher Education Collaboration Council will consider these points.

Recommendation 12

(a) The likely impact of the Research Quality Framework on Australia's science and innovation system with regard to driving innovation and knowledge transfer should be considered.
(b) Areas of knowledge transfer activity that have been designated as extending outside the scope of the RQF should be formally considered as part of the Productivity Commission Review of Public Support for Science and Innovation.

13. Long term certainty of budget commitment.

The Australian government spends approximately $4.18 billion dollars per annum on support for science and innovation, (not including business sector R&D figures).[32] A substantial amount of this support is provided in the form of short term funding or non continuing research grants. Given the long and often bumpy road to market, the lack of long term funding for research, innovation and development is often a disincentive for institutions and businesses to undertake

[32] Productivity Commission. 2006, *Issues Paper – Public Support for Science and Innovation.* Canberra.

research and knowledge transfer activities. A model needs to be developed which provides more certain longer term funding for research and knowledge transfer.

Recommendation 13
Australia needs to develop a model for public funding of science and innovation which provides more certain longer-term funding for research and knowledge transfer.

In conclusion

Moving to 'first tier innovator' status is critical for Australia, if we as a nation want to remain competitive. To strengthen economic performance into the future requires a concerted effort to increase collaboration, raise business spending on research and development, and to greatly improve the efficiency with which publicly funded research and development is converted into commercial and economic outcomes. Establishing Australia as a 'first tier innovator' nation requires continued investment in the national education, knowledge transfer, innovation, and commercialisation environment. Australia's future prosperity rests in the skills and capabilities of its people. An enabling environment is the result of a combination of variables including well trained people, an innovation oriented corporate investment climate and strong collaboration between research organisations and business.