University of
South Australia

Review of the National Innovation System

Submission from the University of South Australia

30th April, 2008

Submission Information

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Declaration of Interest: Interests and affiliations relating to the subject of the Review and the representations contained within this submission are associated with my role as Vice Chancellor of the University of South Australia.

EXECUTIVE SUMMARY

Global Research and Innovation Performance

- It is time for Australia to stop focussing on having a small number of universities rank at the top of league tables based on historical measures of research performance and to start focussing on what is required to build 'a top-ranked university system'. This will include developing an internationally bench-marked metrics system with key performance Indicators (KPIs) that reflect Australian innovation needs and the regular assessment of our performance against those KPIs.
- Australia should set a target of 3% of GDP for investment in R&D (GERD) recognising that research productivity is driven by investment and a strong competitive system that rewards excellence wherever it occurs.
- Australia should invest on a 'whole of country' basis in at least one major international consortium funded to deliver the scale and focus required for globally competitive research and innovation in national priority areas.

Knowledge Transfer/Engagement/Translation/Adoption

- Knowledge transfer activities need to be recognised, funded and systematically embedded so that they become integrated into the mission and strategic plans of all of Australia's Universities and research agencies. There is also a requirement for the training of a new workforce to support this critical element of the national research and innovation system.
- It is important to ensure that any funding mechanisms associated with the introduction of ERA or similar exercises do not act as a disincentive for institutional and individual engagement in multidisciplinary research and in collaboration with a range of partners.
- Reward and promotion systems must be put in place which ensure that the next generation of Australian researchers (including Future Fellows and ARC and NHMRC fellows) and their institutions work collaboratively and engage with a range of external stakeholders.

Innovative Industries, Business, Government

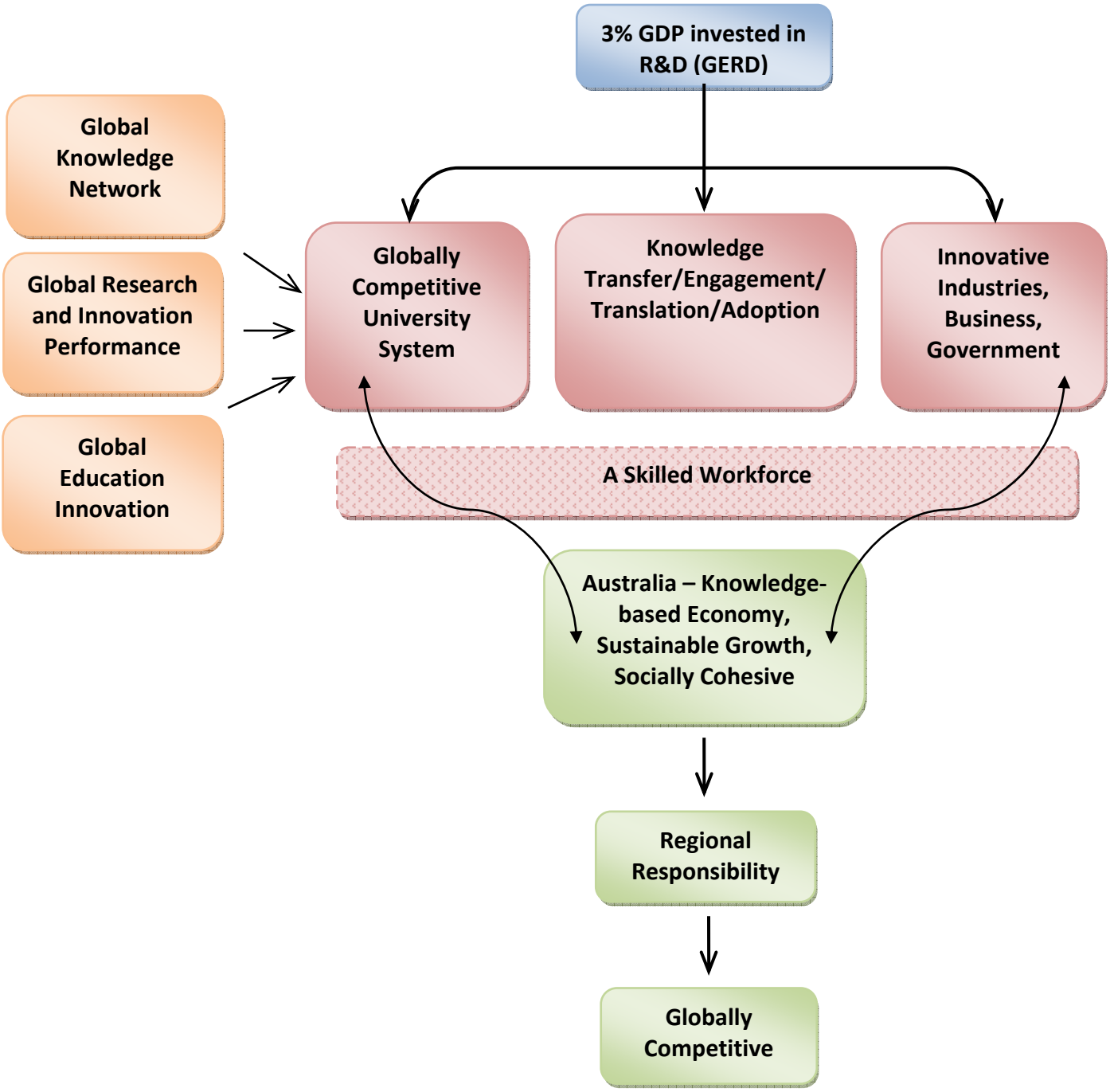
- An Australian Regional Research and Innovation Cluster strategy should be introduced to enhance engagement of small and medium enterprises (SMEs) and build researcher-industry relationships.
- An industry supported PhD Placement Program should be launched to build a cohort of 'innovation catalysts' in Australian industries.

A Skilled Workforce

- A Research and Innovation Workforce Road Map for Australia should be developed which integrates the workforce requirements of the National Innovation System for 2010-2020. The role of each university in building the research and innovation workforce in their areas of strength can then be addressed through mission based compacts.

- It is time for a national coordinated effort to increase the participation, retention and advancement of women in careers in all science, technology, engineering and mathematics (STEM) related fields in industry, business, government and the professions in Australia. The Hypatia Centre of the Royal Institution Australia offers one such opportunity.
- Australia should graduate 20 PhDs per thousand head of the population. The Research Training Scheme should be augmented and overhauled to become the 'Research and Innovation Training Scheme' which would provide support for HDR students to engage in graduate certificate or other professional training courses which would prepare the HDR graduate for a range of professional destinations.
- A professional body should be established which would have oversight of the requirements, work conditions, and accountability of the 'research and innovation professional' and which would communicate the high value of all professionals within the research and innovation career streams.
- Australia should calibrate its strategic research allocation to universities against international benchmarks and move to increase the research block grant funding to 55c for each dollar earned.
- Funding to the ARC must be at the level which allows a 30% success rate in its major funding schemes and the recommended funding level for each grant should be at the level required to enable the research plan to be carried out within a competitive timeframe.
- Australia should invest through NCRIS and HEEF in the next generation of 'Platforms for Education and Research Collaboration' to underpin a transformational change in the networked nature of Australia's education system and enable universities to connect seamlessly with business, school, industry and other research and university partners.

A Summary of the Key Components of a National Research and Innovation System: Making the System Work



Can we imagine a better world? Are we asking the right questions?

What should we learn from international benchmarking?

Australia traditionally benchmarks the performance of its higher education and innovation systems against those in the US and UK. There are countries however, with smaller but strong economies such as Switzerland, Denmark, Sweden and Finland which have relatively high levels of government and business investment in R&D (Table 1) and high research productivity (Fig 1). Interestingly these countries, which perform highly in R&D, do not have Universities in the 'top' 20 group of the Shanghai Jiao Tong World University Rankings.

Table 1: Government and Business Investment in R&D.
(Sources: Number of 'Top' 20 Universities: Shanghai Jiao Tong University rankings. GDP per capita: Department of Foreign Affairs and Trade: Source: http://www.dfat.gov.au/geo Current Account Balance: Source: http://www.worldbank.org/globaloutlook GERD and BERD as a % of GDP: Source: Main Science and Technology Indicators, Vol 2007/2, ISSN 1011 – 792X.)

	GDP per capita (US$) 2007 IMF/EIU Forecast	*Current Account Balance as % GDP 2006*	*GERD as % GDP 2005*	*BERD as % GDP 2005*	*Number of 'Top 20' Unis*
Australia	***42,553***	***-5.3***	***1.76***	***1.04***	***0***
Denmark	***57,035***	***2.5***	***2.45***	***1.67***	***0***
Finland	***44,912***	***6.1***	***3.48***	***2.47***	***0***
Sweden	***47,069***	***7.3***	***3.89***	***2.88***	***0***
Switzerland	***56,711***	***16.3***	***2.93***	***2.14 (2004)***	***0***
The Netherlands	***45,429***	***8.3***	***1.8***	***1.01***	***0***
United Kingdom	***45,301***	***-3.6***	***1.76***	***1.09***	***2***
United States	***45,594***	***-6.6***	***2.62***	***1.83***	***17***

Whilst we believe in the development of metrics that reflect Australia's needs and that reflect appropriate international benchmarking – there are significant concerns that Australia may set the drivers within its $15+ billion higher education industry to chase rankings in either poorly designed or historically referenced world ranking systems. The publication of the *Berlin Principles on Ranking of Higher Education Institutions* (2006) and the current work of the OECD examining how the full range of activities which diverse institutions engage in, notably teaching and learning, should be measured in rankings are positive developments, but will take time before they inform new objective ranking systems. We would suggest that it is time for Australia to move on from a preoccupation with building up the performance of individual universities to building the performance of the overall university system. The development of a top university system will ensure that Australia has sufficient scale and quality in education and knowledge generation to provide sufficient skills, productivity and innovation to underpin a strong economy.

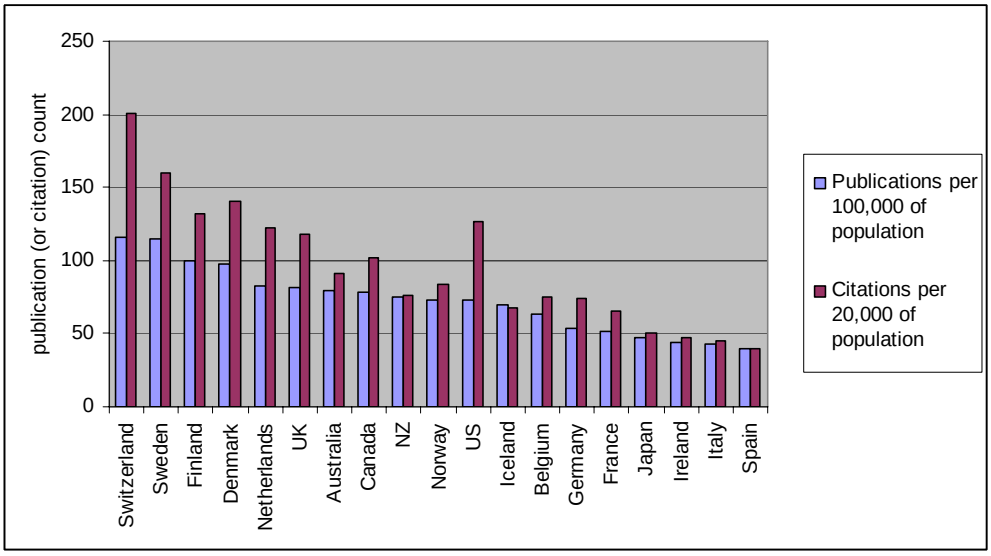


Fig 1: Publications and Citations per Capita by OECD Countries, 2003.
(Source: Barlow, T. 'The State of Research in Australian Universities' 2007.)

The importance of investment in R&D

In Lisbon March 2000, EU heads of state and government agreed on making the EU "*the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion".* The Lisbon Summit agreed that this required a necessary investment in R&D - 3% of GDP. Between 1991-2004, total investment in R&D in China grew thirteen-fold and India passed the 1% threshold for GERD as a percentage of GDP in 2004.

Recent analyses highlight that there is a direct correlation between the level of national investment in university R&D and the quantity and quality of research outputs in the OECD (Fig 2). This is also the case in Australia (Fig 3). This provides reassurance that the principle of investing in the best research projects irrespective of institutional provenance is sound and that an increased investment in the Australian university sector will result in increased standing and performance in research on the world stage.

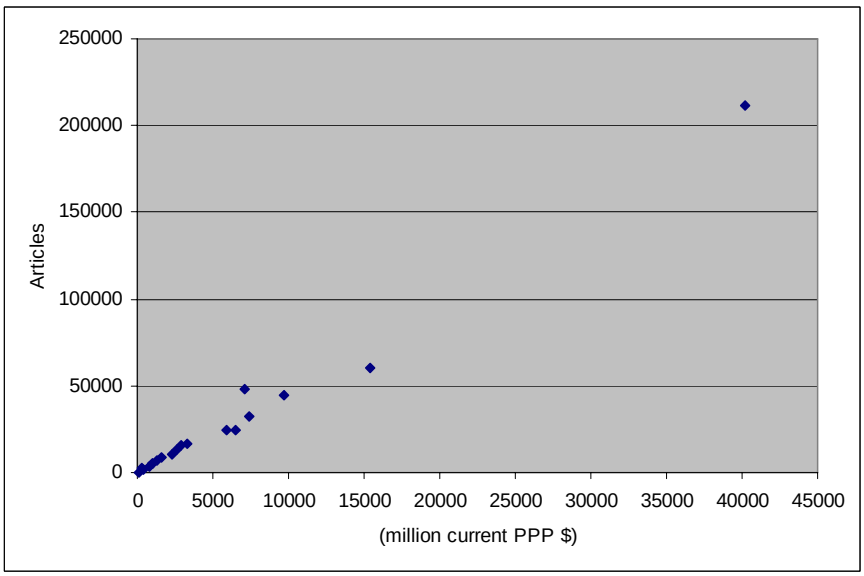


Fig 2: OECD data on the number of publications related to national investment in R&D.
(Source: Barlow, T. 'The State of Research in Australian Universities' 2007.)

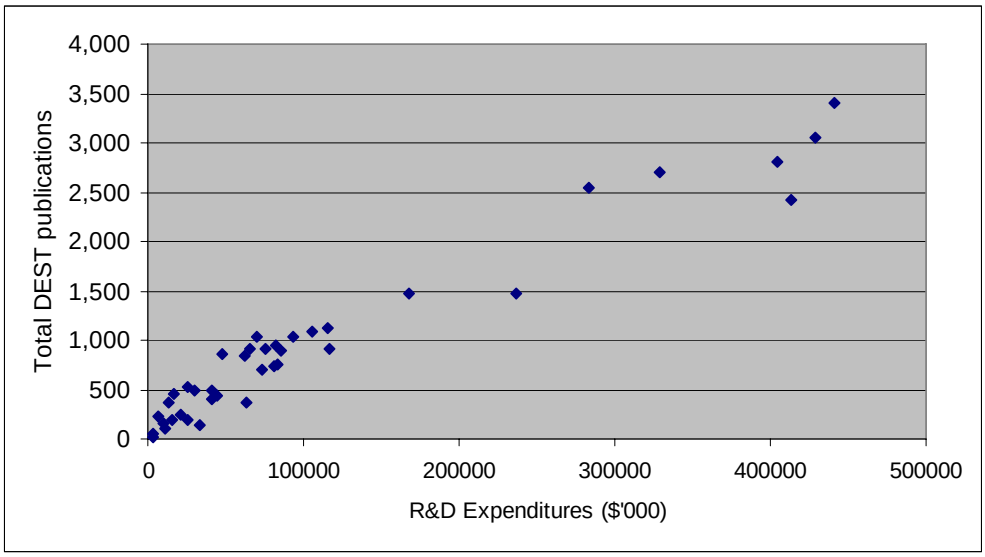


Fig 3: Publications from Australian Universities related to University R&D expenditure data derived from the ABS.
(Source: Barlow, T. 'The State of Research in Australian Universities' 2007.)

Who are our global partners in research and innovation?

Australia risks being isolated in the global innovation system - Australia has found it difficult to get significant traction in the EU Framework Programme and its investment in partnerships with India and China have been fragmented and dependent on relationships between individual entities or researchers. It is time for Australia to establish and support international consortia of the scale required to meet the global innovation challenge. It would be worthwhile exploring whether Australia could engage as a funding partner in new major international consortia on a 'whole of country' basis. While being cognisant of the need to engage decisively with China and India, two interesting options for such partnerships include:

- Canada – based on shared history, similar geographical challenges, resources base and research and business structures;
- The Nordic countries - two countries with the highest percentage of GDP diverted into venture capital are Denmark (0.4%) and Sweden (0.3%) with the US ranked third (0.3%). While 33% of Finnish firms collaborate with higher education institutions only 2% of Australian firms do so. A research based consortium including Australia, Denmark, Sweden and Finland would therefore offer opportunities for Australia to collaborate in world class research and gain insights into how high level design can add significant value to manufactured products (e.g. Bang and Olufsen, Volvo, Ericsson, Nokia etc).

Such international consortia will result in:

- Building of 'research and innovation clusters' of sufficient scale to provide definitive national strategies, eg: the development of national preventive health agenda based on data derived from large scale population studies;
- Encouraging exchange of research talent between Australia and partners; and
- Building a broader experience in engagement and translation of research, eg: through internship placements with international industries which do not have a major presence in Australia.

Key Actions

- **It is time for Australia to stop focussing on having a small number of universities rank at the top of league tables based on historical measures of research performance and to start focussing on what is required to build 'a top-ranked university system'. This will include developing an internationally bench-marked metrics system with key performance indicators (KPIs) that reflect Australian innovation needs and the regular assessment of our performance against those KPIs.**

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Knowledge Transfer/ Engagement/ Translation/ Adoption

How do we solve the big challenges we face as a country, an industry, or as a community?

Regional access to global knowledge - the importance of universities and knowledge transfer

The global availability of knowledge does not guarantee its national, regional or local availability. A recent study found that there was almost no spillover value in Australia for R&D dollars spent in the G-5 (Fig 4). Similarly it has been calculated that knowledge spillover, meaning the use of knowledge beyond formally contracted parties to the technology development, declines by half on average for every 1200km *(Keller 2002, American Economic Review, 92).* The recent report, '*The Race to the Top: A Review of Government's Science and Innovation Policies' (Lord Sainsbury of Turville October 2007),* concluded that "the paradox is that while innovation is a global phenomenon, the role of regions as the critical nexus for innovation based economic growth has increased". Universities have a critical role to play in the transfer of global knowledge to local and regional industry, business and other external stakeholders.

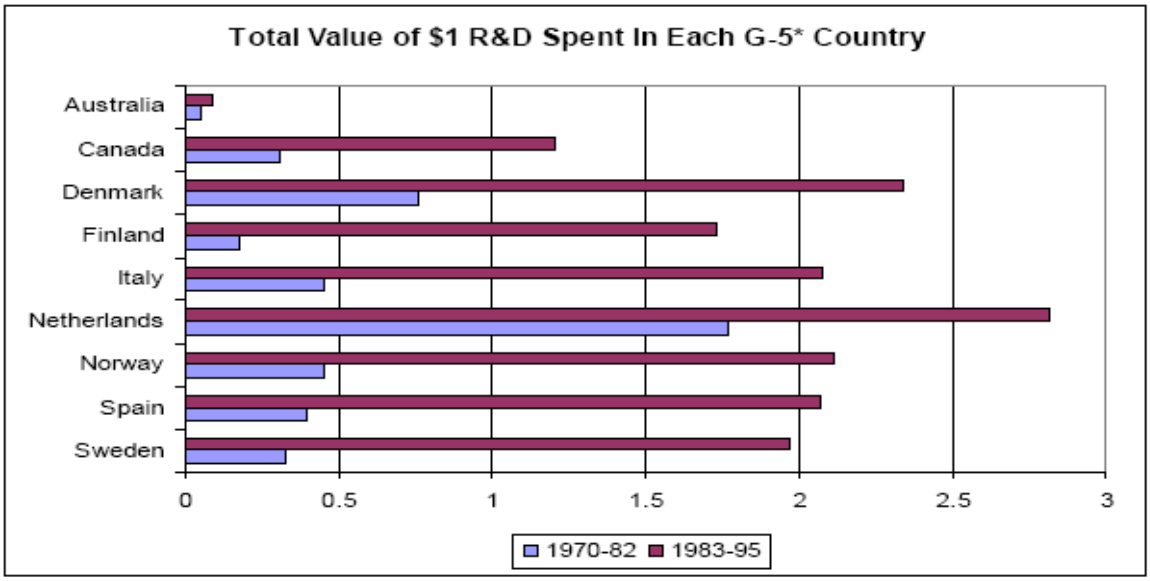

Fig 4: Total Value of $1 R&D Spent in each G-5 Country.

(Source: W. Keller. Geographical Location of International Technology Diffusion, American Economic Review, 92 (1), 2002, pp 120 – 142.)

Knowledge Transfer - The Missing Link

Whilst knowledge transfer activity is a critical component of the innovation system, Australia does not have a framework for the support of effective knowledge transfer – either between public agencies or between public and private organisations.

The Science and Technology Policy Research Unit (SPRU) *Report to the Russell Group* in the UK (2002) drew up a framework which indicated how core university capabilities and activities generate associated third stream activities and developed a list of 12 categories representing all forms of knowledge transfer where universities share their knowledge widely to communities and industry to enhance economic, cultural or regional development, industry/business linkages or sustainability. Importantly these activities extend beyond those related to commercialisation and include contract based research, consultancies and the flow of academic staff, students and scientists between universities and industry, business and community based organisations. This is consistent with the growing recognition that there has been too great a focus on the importance and value of direct commercialisation of publicly funded research *(Productivity Commission: Public Support for Science and Innovation).*

PROPOSED CATEGORIES OF KNOWLEDGE TRANSFER ACTIVITIES
• Technology commercialisation • Entrepreneurial activities • Advisory work • Commercialisation and use of university facilities • Contract research with no academic clients • Non academic collaboration in academic research • Flow of academic staff, scientists and technicians • Student placements • Active alignment of teaching to economic and social needs • Learning activities • Social networking • Non academic dissemination
SPRU Final Report to the Russell Group of Universities, 2002

The SPRU Report also included a streamlined list of possible indicators that could be used to measure the volume of each of these activities within any institution. Australia has no framework in place to support knowledge transfer activities. Whilst there has been some initial work in this area through the Australian Universities Community Engagement Alliance, this is a major policy blind spot in our current innovation system. As highlighted in *The Emerging Business of Knowledge Transfer* (DEST Report; Howard 2005), "The area of university-business-government relations should give a priority to building efficient, practical and effective institutions of engagement (frameworks of rules, roles and relationships) as a foundation for the networks that are needed to underpin Australia's national innovation system".

Aligning Drivers for Collaboration and Engagement

Australia ranks last out of 26 countries in the OECD for research collaborations between industry and universities and second last for research collaboration between industry and public research organisations. We believe it is impossible to move forwards in national innovation while this situation remains and getting the drivers right as expressed through mission based compacts between the higher education sector and the federal government will be important.

The current research and innovation system is fragmented and the challenges in moving forwards include asking:

- Researchers to collaborate with their competitors;
- Non traditional research partners to work across disciplinary boundaries;
- Large publicly funded research agencies to translate collaborative intent into operational processes that support collaboration;
- Research institutions and researchers to establish mechanisms which support productive partnerships with industry and business.

Lack of integration in the research and innovation system results in conflicting signals about desired outcomes. For instance, the foreshadowed Excellence in Research Australia (ERA) exercise emphasises the primacy of 'performance in a discipline' as a measure of research excellence. Whilst the recognition of international excellence is critical in informing the government about the health of research disciplines and in building critical mass in disciplinary areas, there is a clear risk that 'discipline based' research and research training will be perceived by many universities as the only game in town. It is therefore possible to drive institutional and

researcher behaviours on the basis of historical performance measures alone and to ensure researchers consider that interdisciplinary or cross disciplinary research collaborations are of limited value. This is a significant issue at a time when research questions of major national priority (such as climate change adaptation, combating the obesity epidemic) demand input from a range of disciplines.

While we encourage objective and properly executed measurement of performance, there is a clear risk that the introduction of ERA will result in the establishment of 2 'classes' of researchers - those who are recognised for performing well in ERA or similar exercises through intense single minded attention to traditional research performance measures, and those who may take time out to work with research partners in industry and business and then find that these activities are of less value in their profession.

There is also a risk that the rewards for institutions to support the pursuit of excellence in discipline specialisations will be significantly greater than those for supporting researchers engage and collaborate with industry and other end user partners – often with a necessary multidisciplinary approach to tackle complex 'real world' problems. This could have inadvertent negative consequences for the training of the next generation of researchers.

Key Actions

- **Knowledge transfer activities need to be recognised, funded and systematically embedded so that they become integrated into the mission and strategic plans of all of Australia's Universities and research agencies. There is also a requirement for the training of a new workforce to support this critical element of the national research and innovation system.**
- **It is important to ensure that any funding mechanisms associated with the introduction of ERA or similar exercises do not act as a disincentive for institutional and individual engagement in multidisciplinary research and in collaboration with a range of partners.**
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Innovative Industries, Business, Government

How do we get more firms and organisations to use the best available tools and techniques from anywhere around the world in what they do?

Two main limiting factors in innovation include the:

- Relatively low BERD expenditure (as a % of GDP) in Australia (1.04%) compared to the OECD (1.5%);
- Low rate of collaboration between Australian industry and the research sector - only 2% of Australian industry collaborates with the research sector compared to >10% in other successful small countries.

As highlighted in the recent 2007 OECD Report (*Innovation and Growth: Rationale for an Innovation Strategy)*, low rates of researcher mobility between the private and public sectors remains a major bottleneck to knowledge flow in many countries. Policies to enhance science-industry relationships must be part of an overall strategy addressing the business sector's demand for the results of public research. It is clear that we need more highly educated people in Australian business with the insights into, and ability to connect with, universities.

Research and Innovation Clusters

During the last decade there has been a growing awareness in the OECD and in major European, US, and Australian funding agencies that the innovation performance of enterprises is reinforced when they form clusters and networks. Clustering is often seen as a key means of driving regional development - of building private and public sector partnerships - through government and regional investment in innovation incubators, science parks and cities, technology transfer offices, etc. There has been extensive work on the factors which underpin successful innovation clusters and these include: the presence of functioning networks and partnerships; a strong innovation base with supporting R&D activities; and the existence of a strong skills base (*A Practical Guide to Cluster Development: Department of Trade and Industry Report,* UK 2004). There are many other high profile examples of the formation of successful regional innovation clusters, eg: Cambridge, Silicon Valley, Massachusetts and the Fraunhofer-Gesellschaft. The Fraunhofer-Gesellschaft sponsors the formation of regional innovation clusters in which companies and research institutions are brought together in areas of technology with high innovation potential with the support of the federal ministry of education and research.

A national research and innovation framework could include support for:

- Building strong Regional Research and Innovation Clusters in coordination with Enterprise Connect and Researchers in Business initiatives;
- An industry supported 'PhD placement program' to boost the number of PhD educated personnel in the Australian economy employed by industry and enhance the 'connectivity' between industry/enterprises and university research by employment of recently graduated PhDs. Such a scheme would enable, for instance, CRC based industries to capture the graduates who have worked on industry related projects through the course of their PhD.

The Australian Technology Network (ATN) group of universities have recently put forward a proposal for a 50:50 co-investment between government and enterprise for employment of recently graduated PhD candidates as 'innovation catalysts'. In this proposal the government component is linked to the award of a postgraduate scholarship but must be expended for the purpose of facilitating the transfer of the PhD graduates into enterprises as 'innovation catalysts'. Clearly in this, and similar novel schemes, evaluation should be inbuilt to determine whether enterprises gain value from employment of innovation catalysts and hence will commit

to longer term employment of graduates with a view to enhance innovative capacity and expenditure on R&D in the long term.

Key Actions

- **An Australian Regional Research and Innovation Cluster strategy should be introduced to enhance engagement of small and medium enterprises (SMEs) and build researcher-industry relationships.**
- **An industry supported PhD Placement Program should be launched to build a cohort of 'innovation catalysts' in Australian industries.**

A Skilled Workforce

The importance of education and equipping our people to be creative and innovative, lifelong learning

In the face of the international 'war for talent' Australia needs a superb education system to build the human capital required to support social cohesion and a knowledge based economy.

Australia needs all of its universities to:

- Invest in learning and teaching for innovation;
- Focus on teaching and evaluating skills in the "context of real-world complexity, such as expert thinking – the ability to structure problems, complex communication, learning strategies and self-concept" *(Innovation and Growth: Rationale for an Innovation Strategy,* OECD 2007*);*
- Shift the way education is delivered, from "uniformity in the system to individualising learning, from a focus on provision to a focus on choice, from managing inputs to education towards developing responsibilities and enabling outcomes, from talking about equity to delivery of equity" *(Innovation and Growth: Rationale for an Innovation Strategy,* OECD 2007*);*
- Minimise the disconnection between research and teaching in the university classroom which has accompanied the increase in student: staff ratio from 12.9 (1990) to 20.3 (2005);
- Add value to the experience and potential of each graduate.

These are significant challenges given the ageing demographic of our university workforce and the $3.9bn wage cost funding gap which has arisen in the university system during the past decade.

The key elements required to underpin a superb education system are support for:

- Talented people;
- Fully costed research;
- Infrastructure that provides research and learning environments consistent with 2020, rather than 1820;
- Change and innovation in education and research practice.

People: A Research and Innovation Workforce Road Map for Australia

Given the international war for talent, it would be important for Australia to develop a national research and innovation workforce plan that would inform policy on how to ensure we will have enough research active academics teaching in our universities, enough graduates in the education of school students in science and maths, and enough innovation ready graduates working to add value to new and existing industry sectors.

The absence of a road map for the innovation workforce will be particularly limiting in the science, technology, engineering and mathematics fields at a time when international investment in these fields is escalating, including in the large economies of India and China.

There are also significant changes occurring in all professions around the nature of professional work. For example in engineering, future developments are likely to see routine engineering work being sourced from China, India or Russia with the challenge for countries such as Australia to add high value to products through integration of concepts in design and

innovation. This will require professionals trained in an education system infused with research and innovation and exposed to major cross disciplinary problems.

Australia currently has 8 PhDs per thousand head of population compared to 11 in the US, 20 in Germany and 28 in Switzerland. Growing a skilled workforce will mean growing more numbers of postgraduates and developing a greater range of destinations for the PhD graduate including careers which include periods of time contributing to different elements of our national research and innovation system. Our Higher Degree Research (HDR) system has to build the capacity required for Australia to solve complex multidisciplinary problems which have not yet been identified, rather than recreate disciplines and academic dynasties of the past. Disincentives to undertaking training in innovation and research – including a low living stipend and conflicting tax regulations - have to be systematically addressed.

People: Recruiting all of Australia's Innovation Talent

A range of recent international studies have highlighted the difficulties in recruiting, retaining and promoting the interest of women in science, engineering and mathematics (STEM) careers. These issues have moved from being ones of individual equity to ones of relevance to the national skills shortages in key industry areas including defence, advanced manufacturing, mining, and engineering etc. Recent work in the OECD, UK, US, and Australia has shown very similar trends in the difficulties faced by industries in the recruitment and retention of women graduates in the STEM areas.

Collectively, studies have shown that there is/are:

- A world-wide skills shortage in STEM areas;
- Low participation of girls and women in STEM subjects in secondary and tertiary education;
- Specific issues which limit the recruitment and retention of women in STEM careers;
- Employer practices that appear to discourage women's full participation in STEM careers;
- Low numbers of women achieving senior ranks within STEM careers;
- Low recognition of women's achievements in the science community.

In addition, there is a set of other barriers that have been identified as being important in limiting women's full participation in science-related careers. These include:

- Lack of flexible working hours;
- Minimal career development and training;
- Issue relating to equal pay for equal work;
- Lack of quality child-care;
- Demands for excessive hours of work;
- Cultural issues in workplaces in which women can be the minority;
- Perception of women as leaders.

It is time for a national coordinated effort to increase the participation, retention and advancement of women in careers in all science, technology, engineering and mathematics (STEM) related fields in industry, business, government and the professions in Australia. One such initiative positioned to address this is the proposed Hypatia Centre, operating as part of the Royal Institution (Australia). The Centre will work to draw together existing activities and initiatives at both State and national levels to enable better coordination of effort and the

strategic targeting of resources and trialling of evidence based intervention programs. This is a timely and important initiative.

People: Building Research and Innovation Capacity

It is also time to ensure that the Australian PhD does not remain a 'one size fits all' degree - there are significant opportunities to 'value add' to PhD training including:

- Intern placements in industry;
- Training in commercialisation (e.g. the ATN Graduate Certificate in Commercialisation), research management, and education of the 'boardroom ready graduate';
- The development of a teaching portfolio (thereby enhancing the teaching-research nexus).

People: Building the Research and Innovation Profession

Research is not a profession. There is no formal post doctoral career path and there is no professional body which has oversight of the career pathways, including entry and exit points into other professions, or of whether individuals have the level of skills required for research leadership, research mentorship, project delivery etc. Predoctoral research assistants comprise a large part of the research workforce – and are routinely employed on successive short term contracts with high wastage to a range of other career roles in times of high employment.

Australia's brightest and best students routinely look to the professions of law, medicine, and engineering etc - rather than aspire to be 'a researcher' in academia, industry or government. If any workforce plan is to deliver the desired outcomes for an innovation system, it is time to change this ad hoc approach to the recognition and valuing of 'the research career'.

Fully Costed Research and Research Infrastructure

Whilst the total research income earned by Australian universities in 2006 ($2.207 billion) was 21% higher than in 2005 ($1.826 billion) there was only a 2% increase in the associated 'research block grant allocation' provided to universities which is intended to support the 'general fabric of the research and research training activities'.

The current level of research infrastructure funding provided through the Research Infrastructure Block Grant (RIBG) is 23c/$ and this funding is intended to:

- Enhance the development and maintenance of research infrastructure in Higher Education Providers (HEPs) for the support of high quality research in all disciplines;
- Meet project-related infrastructure costs associated with Australian Competitive Grants;
- Remedy deficiencies in current research infrastructure;
- Ensure that areas of recognised research potential, in which HEPs have taken steps to initiate high quality research activity, have access to the support necessary for development.

The above aims of the RIBG scheme are simply not achievable at this funding rate which lags significantly behind the US (45c/$) and UK (55c/$).

Whilst there has been recent increased investment in the NHMRC, investment in the ARC has lagged behind. A 20% success rate in the ARC system, coupled with an at least 30% reduction in allocation of funds to each grant compared to the full costs of the research, means that there is high wastage in the system. This will be compounded if plans to reinvigorate Australia's research workforce succeed through the Future Fellowship and other schemes. It is critical that, having attracted high performing researchers to Australia, their research has a greater than 1 in

5 chance of being funded and at a funding level which will enable them to complete the research in a competitive time frame.

The recent national investment in research infrastructure through the National Collaborative Research Infrastructure Strategy (NCRIS) and the proposal to develop the teaching and research infrastructure through the Higher Education Endowment Fund (HEEF) are critical steps in building the next generation of infrastructure required to underpin a superb education system. Both schemes provide necessary elements of a new research and innovation system for Australia.

It may also be appropriate for the HEEF scheme to consider how best to build collaborative networks and partnerships for the delivery of 'best in class' programs, harnessing both e-learning and e-research capabilities. Australia is well positioned to harness the HEEF scheme as a change agent in education and research practice. In this regard strong collaboration between NCRIS and HEEF in relation to the Platforms for Collaboration (ICT) initiative could underpin a transformational change in the networked nature of Australia's education system and enable universities to connect seamlessly with business, school, industry and other research and university partners. Without a coherent 'whole of system' approach to ICT, the full benefits of NCRIS, HEEF and the National Innovation Review will not be realised.

Key Actions

- **A Research and Innovation Workforce Road Map for Australia should be developed which integrates the workforce requirements of the National Innovation System for 2010-2020. The role of each university in building the research and innovation workforce in their areas of strength can then be addressed through mission based compacts.**

- **It is time for a national coordinated effort to increase the participation, retention and advancement of women in careers in all science, technology, engineering and mathematics (STEM) related fields in industry, business, government and the professions in Australia. The Hypatia Centre of the Royal Institution Australia offers one such opportunity.**

- **Australia should graduate 20 PhDs per thousand head of the population. The Research Training Scheme should be augmented and overhauled to become the 'Research and Innovation Training Scheme' which would provide support for HDR students to engage in graduate certificate or other professional training courses which would prepare the HDR graduate for a range of professional destinations.**

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Continued over

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