The Senate

Economics References Committee

Australia's Innovation System

Interim report

August 2015

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Senate Economics References Committee

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Dr Sean Turner, Principal Research Officer (until 5 July 2015)
Ms Morana Kavgic, Administrative Officer (until 27 February 2015)
Ms Ashlee Hill, Administrative Officer (from 23 February 2015)

PO Box 6100
Parliament House
Canberra ACT 2600
Ph: 02 6277 3540
Fax: 02 6277 5719
E-mail: economics.sen@aph.gov.au
Internet: www.aph.gov.au/senate_economics

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Interim Report

Referral of inquiry

1.1 On 18 March 2014, the Senate referred the following matter to the Senate Economics References Committee (committee) for inquiry and report by the first sitting day of July 2015:

> The challenges to Australian industries and jobs posed by increasing global competition in innovation, science, engineering, research and education, with particular reference to:
>
> (a) The need to attract new investment in innovation to secure high skill, high wage jobs and industries in Australia, as well as the role of public policy in nurturing a culture of innovation and a healthy innovation ecosystem;
>
> (b) The Australian Government's approach to innovation, especially with respect to the funding of education and research, the allocation of investment in industries, and the maintenance of capabilities across the economy;
>
> (c) The importance of translating research output into social and economic benefits for Australians, and mechanisms by which it can be promoted;
>
> (d) The relationship between advanced manufacturing and a dynamic innovation culture;
>
> (e) Current policies, funding and procedures of Australia's publicly-funded research agencies, universities, and other actors in the innovation system;
>
> (f) Potential governance and funding models for Australia's research infrastructure and agencies, and policy options to diversify science and research financing;
>
> (g) The effectiveness of mechanisms within Australian universities and industry for developing research pathways, particularly in regards to early and mid-career researchers;
>
> (h) Policy actions to attract, train and retain a healthy research and innovation workforce;
>
> (i) Policy actions to ensure strategic international engagement in science, research and innovation; and
>
> (j) Policy options to create a seamless innovation pipeline, including support for emerging industries, with a view to identifying key areas of future competitive advantage.

1.2 On 24 March 2015, the Senate granted an extension to the committee to report by 10 August 2015. On 15 June 2015, the committee received a further extension to report by 15 October 2015.

Conduct of inquiry

1.3 The committee advertised the inquiry on its webpage and in *The Australian*, calling for submissions to be lodged by 31 July 2014.

1.4 To date, the committee has received 181 submissions and has held four public hearings.

1.5 The committee has agreed to table this interim report and to request an extension to present a final report no later than 25 November 2015.

Context of inquiry

1.6 The Organisation for Economic Co-operation and Development (OECD) guidelines on innovation data (the Oslo Manual) defined innovation as the 'implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations'. It added:

> This broad definition of an innovation encompasses a wide range of possible innovations…The minimum requirement for an innovation is that the product, process, marketing method or organisational method must be new (or significantly improved) to the firm. This includes products, processes and methods that firms are the first to develop and those that have been adopted from other firms or organisations.[1]

1.7 The Commonwealth Scientific and Industrial Research Organisation (CSIRO) noted that, while innovation is defined broadly as the 'process of translating an idea or invention into a good or service that creates value, and for which a customer will pay, it is not an end in itself: it is a means to an end'. CSIRO continued:

> The ends can be a broad range of economic, social and environmental benefits that drive national wellbeing, prosperity and development, including through the development of new products and services, better functioning societies or through improved public sector productivity.[2]

1.8 As a case in point, Engineers Australia highlighted that innovation in engineering encompasses an 'end-to-end process, such that it extracts value through implementation'. It noted that innovation involves:

- Creating or generating new activities, products, processes and services.
- Seeing things from a different perspective.
- Moving outside the existing paradigms.
- Improving existing processes and functions.
- Disseminating new activities or ideas.

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1 OECD and Eurostat, Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd edition, 2005, p. 46.

2 Commonwealth Scientific and Industrial Research Organisation, *Submission 36*, p. 4.

- Adopting things that have been successfully tried elsewhere.[3]

1.9 Innovation is fundamental to Australia's growth and preparedness for emerging social, economic and environmental challenges.[4] The Productivity Commission has noted that innovation and 'diffusion of new and better production methods, and the introduction of new goods and services, are the core drivers of productivity growth — getting more, and more highly valued, outputs from any level of inputs'.[5]

1.10 The OECD has stated that the 'capability to innovate and to bring innovation successfully to market will be a crucial determinant of the global competitiveness of nations over the coming decade'. It noted that innovative activity is 'the main driver of economic progress and well-being'.[6]

1.11 Similarly, Professionals Australia noted that innovation is 'a driver of both productivity and economic growth as shown by the United States where half of the economic growth in the last 50 years can be attributed to scientific innovation, despite a decline in mining productivity'.[7]

1.12 The point was made in evidence to the committee that an innovation system is crucial to driving national productivity and competiveness and to generating national wealth.[8] CSIRO highlighted that:

> With over 60 per cent of Australia's productivity growth due to innovation, it is clear that Australia's future prosperity in large part relies on the ability of our innovation system to translate research and development outputs into innovative new products and services that enable Australia to remain internationally competitive.[9]

1.13 Innovation has had a positive impact on Australia's economy 'with strong relationships demonstrated between innovation and productivity growth, firm competitiveness and trade'.[10] In 2007, the Productivity Commission found that around 65 per cent of economic growth per capita from 1964–65 to 2004–5 could be ascribed

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3 Engineers Australia, *Submission 46*, p. 4.

4 Department of Industry, *Submission 110*, p. 5; Engineers Australia, *Submission 46*, p. 10; Ernst & Young, *Submission 52*, pp 2–3; Community and Public Sector Union and the CSIRO Staff Association, *Submission 159*, p. 5.

5 Productivity Commission, *Annual Report 2007–08*, 2008, p. 1.

6 Organisation for Economic Co-operation and Development, *Innovation and Growth – Rationale for an Innovation Strategy*; cited in Ernst & Young, *Submission 52*, p. 3.

7 Professionals Australia, *Submission 117*, p. 4. See also Engineers Australia, *Submission 46*, p. 3.

8 Mr Craig Roy, Commonwealth Scientific and Industrial Research Organisation, *Committee Hansard*, 27 July 2015, p. 1.

9 Commonwealth Scientific and Industrial Research Organisation, *Submission 36*, p. 4.

10 Innovation Australia, *Submission 157*, p. 2.

to improvements in the country's use of capital and labour, made possible by innovation.[11]

1.14 Nevertheless, the point was made that a key determinant in lifting the country's productivity performance going forward will be how effectively we unleash innovation.[12] In this regard, Australia's history of research and technological advancement was highlighted, given the country's highly educated population and world-class research facilities.[13]

1.15 The Community and Public Sector Union and the CSIRO Staff Association made the point that as almost all modern activity is influenced or facilitated by scientific innovation, 'any society that devalues or rejects science and innovation, will be left behind'.[14] The Australian Academy of Technological Sciences and Engineering noted that Australian industry 'must be prepared to embrace innovation and research'.[15] The Department of Industry suggested that innovation 'requires sustained effort from both private and government sectors':

> …not only to invest in new ideas, but to build capacity to be able to execute those ideas. Where there are market failures, government is well placed to assist and facilitate improved economic outcomes.[16]

1.16 According to the Community and Public Sector Union and the CSIRO Staff Association:

> A strategic approach to diversify and build scientific capabilities for Australia's interests would maximise the impact across the whole of government, business and industry sectors.[17]

1.17 However, evidence to the committee emphasised that Australia's innovation capacity is limited by structural and cultural barriers.[18] This reality is reflected in statistics that reveal that only 1.5 per cent of Australian companies developed 'new to the world innovations' in 2011, compared to figures of 10 to 40 per cent for businesses in other OECD countries.[19] As of 2008, an estimated 98 per cent of new technologies were sourced from outside Australia.[20] At the same time, Australia remains a low

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11 Productivity Commission, *Public Support for Science and Innovation*, Research Report, 2007, p. 110.

12 Business Council of Australia, *Submission 175*, p. 3.

13 Professor Ed Byrne AC, Monash University, *Submission 1*, p. 1; Engineers Australia, *Submission 46*, p. 4.

14 Community and Public Sector Union and the CSIRO Staff Association, *Submission 159*, p. 5.

15 Australian Academy of Technological Sciences and Engineering, *Submission 96*, p. 2.

16 Department of Industry, *Submission 110*, p. 6.

17 Community and Public Sector Union and the CSIRO Staff Association, *Submission 159*, p. 41.

18 Chief Scientist for Australia, *Submission 20*, p. 1; Engineers Australia, *Submission 46*, p. 7.

19 Chief Scientist for Australia, *Submission 20*, p. 2. Professional Australia made a similar point—it noted that the figure for New Zealand is 20 per cent. *Submission 117*, p. 4.

20 Cutler & Company, *Review of the National Innovation System*, 2008.

level performer in both business and government expenditure in research and development.[21]

1.18 The inquiry has identified a number of factors which serve as barriers to the flow of ideas, mobility and funding between public and private sectors and ultimately limit or impede innovation. Some of these factors and impediments highlighted to the committee in evidence include:

- A lack of an innovation culture and appetite for risk – as innovation is largely about market experimentation, risk of failure needs to be accepted or at least tolerated.[22]
- Low levels of mobility between business and public sector research and development – only 30 per cent of researchers in Australia work in industry. This figure compares to the OECD average of 60 per cent and the United States figure of 80 per cent.[23] Conversely, only four per cent of Australia's large firms collaborated with research organisations and only a slightly higher proportion of small-to-medium sized enterprises (SMEs).[24]
- Translating Australia's highly regarded research into economic outcomes – the limited commercialisation and conversion of research for economic advantage and the need to ensure that research infrastructure addresses the industrial, social and economic problems of significance to the nation.[25]
- Lower innovative activity amongst SMEs when compared to larger firms – 74 per cent of large businesses in 2012–13 were classified as innovation active, compared to 34.7 per cent of businesses with 0–4 employees, 51 per cent of businesses with 5–19 employees and 63.4 per cent of businesses with 20–199 employees.[26]

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21 Community and Public Sector Union and the CSIRO Staff Association, *Submission 159*, p. 41.

22 Chief Scientist for Australia, *Submission 20*, p. 1; Mr Nick Wong, *Submission 3*, p. 1. Engineers Australia, *Submission 46*, p. 8. The Department of Industry noted that 70 per cent of innovation investment was directed to incremental innovation with 30 per cent directed to radical innovation. While radical innovation generally entails greater risks, the rewards to business and the economy are also generally far more significant. Department of Industry, *Submission 110*, p. 5.

23 Chief Scientist for Australia, *Submission 20*, p. 2. See also Department of Industry, *Submission 110*, p. 18.

24 Chief Scientist for Australia, *Submission 20*, p. 2 Keech Australia, *Submission 17*, p. 2. Australian Council of Trade Unions, *Submission 45*, p. 5.

25 Professor Rachel Parker, Queensland University of Technology Business School, *Committee Hansard*, 27 July 2015, p. 28; Australian Academy of Technological Sciences and Engineering, *Submission 96*, p. 2; Professor Edward Byrne AC, *Submission 1*, p. 1; Queensland University of Technology, *Submission 58*, p. 4.

26 Australian Bureau of Statistics, 'Innovation in Australian Business 2012–13, cat. No. 8158.0.

- An unconducive climate for innovators – such as a lack of support from financial markets; limited skills in business management; difficulty in accessing global supply chains and a poor intellectual property strategy.[27]
- Declining participation rates of Australian students in science subjects and of tertiary students studying science and engineering – Australian ranked 73rd of 143 countries in the *Global Innovation Index 2014* in terms of the percentage of total tertiary graduates that studied science and engineering.[28]
- Challenges in measuring the contribution of the creative industries (including traditional arts, design and architecture sector, new media and digital growth areas) and the importance of cultivating creative skills and linking designers with researchers, educators, enterprises and government.[29]

Purpose of this report

1.19 The purpose of this report is to generate further discussion and evidence regarding Australia's innovation system. As a means of encouraging further debate, the report makes public an issues paper provided to the committee by Professor Roy Green. The paper is provided at Attachment 1.

1.20 Professor Green was contracted by the committee as an expert consultant for the purposes of the inquiry. In publishing Professor Green's issues paper, the committee's intention is provide context to key and emerging issues of relevance to the inquiry, identify and explore some of the challenges and obstacles in relation to Australia's innovation system, and to generate discussion on how these challenges could be addressed. In its final report therefore, the committee will endeavour to identify and explore methods to address these challenges and to forge closer linkages and collaboration between government, industry and research bodies.

27 Chief Scientist for Australia, *Submission 20*, p. 2; Engineers Australia, *Submission 46*, p. 7.

28 Cornell University, INSEAD and WIPO, *The Global Innovation Index 2014: The Human Factor in Innovation*, Country Profile – Australia, 2014, p. 145.

29 Professor Stuart Cunningham, Australian Research Council Centre of Excellence for Creative Industries and Innovation, *Committee Hansard*, 27 July 2015, p. 35; Mr Rod Glover, *Committee Hansard*, 3 August 2015, p. 29. Australian Design Alliance, *Submission 180*, p. 2. The Global Innovation Index identified cultural and creative services exports as a weak variable, ranking the country 52nd in relation to this indicator. Cornell University, INSEAD and WIPO, *The Global Innovation Index 2014: The Human Factor in Innovation*, Country Profile – Australia, 2014, p. 22.

Recommendation

1.21 The committee recommends that the Senate extend the inquiry reporting date to 25 November 2015.

Senator Sam Dastyari
Chair

Attachment 1

Senate Inquiry into Australia's Innovation System
Issues Paper

Professor Roy Green

Senate Inquiry into Australia's Innovation System Issues Paper

Roy Green

ABSTRACT

This Issues Paper is aimed at providing context, identifying issues, and stimulating discussion in relation to the Terms of Reference being addressed by the Senate Economic References Committee in its Inquiry into Australia's Innovation System. The Paper covers the role of a National Innovation System, current levels of investment in research and development, education and skills, industrial transformation, collaboration, the contribution of start-up businesses and management practices. Some policy issues and options are also identified, with a view to activating current and future sources of competitive advantage.

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Summary

This paper provides background to the terms of reference for the Senate Economic References Committee Inquiry into the Innovation System.

The Innovation System

Innovation is, quite simply, the successful implementation of new ideas, or 'ideas successfully applied'.

Innovation thrives in an *Innovation System* - the relationships and interactions between knowledge creating organisations, knowledge adopters, and government (in its policy, funding, enabling, and regulatory roles).

Innovation Systems also reflect *social innovations* that enhance community well-being and the quality of human interaction in cities and regions, and in rural and remote areas.

Submissions to the Inquiry pointed to the growing significance of *innovation ecosystems* forming around universities and research organisations and their importance for the development of technology-oriented industries.

Investment in research and development

The Australian R&D investment environment is complex, reflecting the differing missions and priorities of different players in the system:

- *Business* R&D is heavily oriented towards mining and energy, manufacturing, information and communication services, and commercial services and tourism.
- *University* research is heavily concentrated in health, the social sciences, the environment, and generally, expanding knowledge.
- *Government* R&D (including State Governments) is strongly oriented towards agriculture, mining and energy, health, and the environment

Over the last 12 months, as attention focused on sources of competitive advantage in a post mining boom economy, there is renewed interest in the development of science and research and industry growth priorities, together with a call for universities to give greater commitment to *industry led* research and development.

Many submissions emphasised that this commitment should not compromise investment in the basic research – and particularly research that creates and extends *enabling technologies.*

Industrial transformation

Key enabling technologies - in areas such as micro/ nanoelectronics, nanotechnology, semiconductors, advanced materials, photonics, analytics, artificial intelligence, and biotechnology - have a major impact on the transformation of Australian industry.

All of these technologies embed some element of *digital technology.*

Digital literacy is becoming a key requirement and capability across all industry sectors.

Several submissions noted that in this digital world *design* is integral to making goods and services that meet regulatory requirements, enhance user experiences, create competitive advantage, and, ultimately, deliver economic and social value.

Education and skills

There is a strong view that school-leavers *and* mature age students must be equipped in science, technology and mathematics (STEM) as well as 'boundary crossing' skills like problem solving, adaptability and design thinking in an environment of lifelong learning.

A high quality and integrated tertiary education system, that covers both higher education and vocational education and training (VET), is seen as vital for world-class academic and occupational learning.

New funding models should be developed to simplify collaboration between the two sectors so that university graduates have the opportunity to develop an appreciation of practice, and technicians have an understanding of theory.

Collaboration

Submissions advocate Australian businesses and universities giving greater attention to building deep longer-term *engagement,* developed on the basis of understanding each other's distinctive missions and the creation of trust.

Whilst financial incentives are important, collaboration is likely to be enhanced by the development of personal interactions and relationships between industry and university leaders.

Innovation culture

In a business context innovation is closely associated with a culture of entrepreneurship – the ability to visualise and create economic value through the application of ideas and insights about market behaviours and customer wants.

Submissions have noted that it is important to build and strengthen Australia's *innovation and entrepreneurial culture*. This could include celebrating the success of entrepreneurs in business and community achievement – rather than admiring those who secure riches through capital gains and luck.

System leadership

Several submissions suggested that Innovation System performance could be improved through a national body having responsibility for developing an overarching strategy and plan and encouraging a coordinated approach to innovation investment. It could engage with all institutions in the System and build *consensus* about ways to deliver system outcomes, including productivity improvement and international competitiveness.

1 Introduction

Inquiry terms of reference

On 18 March 2014, the Senate referred an inquiry into Australia's Innovation System to the Senate Economics References Committee. The Senate has agreed that the report should be tabled by 15 October 2015.

The inquiry terms of reference require the Committee to address the challenges to Australian industries and jobs posed by increasing global competition in innovation, science, engineering, research and education. Specific terms of reference are set out below.

Box 1: Inquiry Terms of Reference

Senate Economics References Committee Inquiry into the Innovation System

(a) The need to attract new investment in innovation to secure high skill, high wage jobs and industries in Australia, as well as the role of public policy in nurturing a culture of innovation and a healthy innovation ecosystem;
(b) The Australian Government's approach to innovation, especially with respect to the funding of education and research, the allocation of investment in industries, and the maintenance of capabilities across the economy;
(c) The importance of translating research output into social and economic benefits for Australians, and mechanisms by which it can be promoted;
(d) The relationship between advanced manufacturing and a dynamic innovation culture;
(e) Current policies, funding and procedures of Australia's publicly-funded research agencies, universities, and other actors in the Innovation System;
(f) Potential governance and funding models for Australia's research infrastructure and agencies, and policy options to diversify science and research financing;
(g) The effectiveness of mechanisms within Australian universities and industry for developing research pathways, particularly in regards to early and mid-career researchers;
(h) Policy actions to attract, train and retain a healthy research and innovation workforce;
(i) Policy actions to ensure strategic international engagement in science, research and innovation; and
(j) Policy options to create a seamless innovation pipeline, including support for emerging industries, with a view to identifying key areas of future competitive advantage.

The Inquiry has received 178 submissions: 60 were from research and teaching organisations (university, publicly funded research organisation, TAFEs), 43 from businesses, 16 from industry associations, five from workplace organisations, 20 by consultants, and the remainder from interested individuals.

Purpose of this paper

The purpose of this Paper is to stimulate discussion and provide some supplementary material where there are gaps in submission coverage.

Whilst the high level of contribution from universities and research organisations and business could be expected, the lack of input from technology investors and enabling infrastructure agencies is disappointing. There were no submissions from plant or animal production industries or the food industry.

The Rural RDCs, either individually or collectively did not make submissions. And, apart from a submission from the Australian Private Equity and Venture Capital Association, there were no submissions from venture capital and other technology investors, or from the broader finance sector.

Previous Innovation System reviews and inquiries

Over the last 15 years there have been at least 60 Commonwealth government or ministerial policy statements, government commissioned reports, reviews, and information papers that address Innovation System issues.

There is a copious quantity of unpublished consultants' reports prepared for government, as well as a portfolio of research reports, position papers, and advocacy documents issued by industry organisations, professional services businesses, academic associations, and learned academies.

The volume of this material reflects the widespread and continuing interest in innovation in business, government and the research sector.

2 The Innovation System

The term *Innovation System* is generally used to describe the flow of technology, knowledge, and information among people and organisations that assist firms to innovate. Innovation Systems operate at the national, regional and local level.

Establishing and maintaining connections through networking, commercialisation, and collaboration are major issues in the analysis of Innovation Systems.

Innovation system scope

In essence, an Innovation System is about the relationships between knowledge creating organisations (principally research and teaching organisations) and knowledge adopters (industry, and the businesses that constitute it) and

government (in its policy, funding, enabling, and regulatory roles).

Financial organisations, including venture capital investors, innovation intermediaries, professional advisers, and consultants play an important enabling and integrating role.

The Innovation System cannot be said to work 'systematically'. It is dynamic and multidimensional and relationships are constantly changing.

For example, policies determined and decisions taken in one part of the System that might seem like a good idea by some could have potentially adverse effects in other parts of the System and impact on the course of technological progress.

Innovation and technological progress

Economists are interested in innovation because of the link between technological progress and economic prosperity. They take a close interest in the level of national investment in research and development (R&D) on the expectation that this will lead to scientific discoveries and technological inventions that will be adopted and applied to create new industrial infrastructure and a new range of producer and consumer goods and services.

Strengthening *institutional capability* within the Innovation System to ensure that investment in R&D is translated into business outcomes that deliver firm level and national productivity improvement and international competitiveness are key issues for consideration.

In the contemporary environment technological progress is *knowledge, or theory, based.* It draws strongly on *research* undertaken in the natural, physical and life sciences, engineering, and mathematics. This research is often reflected in a range of *platform and enabling technologies.*

Many of these advances can be traced to public investment in basic, or fundamental, research undertaken in large-scale (and expensive) research facilities.

Increasingly, technological progress embraces the application of *digital* technologies and the ability to develop and/or apply software, instruct machines on how to use it, and to secure access to substantial computer processing power - economically and efficiently. Digital technologies are also a critical enabler in modern design practice.

From a business perspective innovation is closely associated with a culture of entrepreneurship – the ability to visualise and create business value through the application of ideas and insights about market behaviours and customer wants.

Entrepreneurs often pull through and apply advances in technology to capture business opportunities. Their understanding of these technologies might have been developed through research, formal education and training, interaction with colleagues, or through social networks.

Firms that don't innovate tend to fold as they lose customers and markets – unless they are protected in some way from the forces of competition, are comfortable with operating in a continual survival mode, or are following a lifestyle choice.

Some nations and regions have been better than others in capturing the benefits of technological progress. This can be linked in large part to the design and implementation of innovation policies.

Innovation policy

The division of policy responsibilities and accountabilities for innovation in Australia is highly distributed. The Commonwealth Minister for Industry and Science has a lead role with portfolio responsibilities for manufacturing, energy, resources, and Intellectual Property.

Other Minsters also have policy roles, including the Ministers for Agriculture (rural research), Communication (ICT), Defence, Education and Training, Trade (exports and export development), Health (medical research), Infrastructure (Regional Development Australia) and Treasury (CGT, capital market issues). The Attorney General has some role in arts and design policy.

The State and Territory Governments are important players in innovation and several have Ministers with an innovation policy role. States are generally responsible for Vocational Education and Training and are major investors in primary industries and medical research.

Local governments have major responsibilities that affect innovation, including local economic development, control over land use, property development, and building regulation and control.

From another policy dimension, research and education institutions operate independently (with some coordination through peak bodies). Industry is also multifaceted, with representation from several peak bodies and a plethora of sectoral industry associations and lobby organisations.

Numerous professional associations (engineers, architects, computer professionals, etc.) also contribute to this heavily pluralist approach to policy development and implementation.

From Innovation Systems to clusters and ecosystems

Clusters of business and commercial activity have been a feature of industrial innovation for many centuries. They have enabled sharing of physical infrastructure, access to talented artisans, and contact with markets. Firms within clusters have tended to be fiercely competitive, which is seen to result in greater efficiencies and opportunities for sustained growth.

Geographic clustering is important in current science technology and innovation contexts. Clusters emerge around technology corporations, technology entrepreneurs, university based researchers, and venture capital investors. Silicon Valley on the West Coast of the US, as well as the Boston area on the East coast, and the Cambridge area in the UK, are the most notable examples of this combination.

Clusters are increasingly being referred to as innovation 'ecosystems'. In a global context, these places are seen as having the potential to create lots of local jobs and wealth, particularly if start-ups are to mature and emerge with a global orientation.

Innovation ecosystems highlight the significance of informal interactions and connections between people in research, business, and investing organisations, and the emergence of 'social capital'.

Innovation system governance

Across Australia there are numerous Councils, Committees and Boards that seek to set policies, priorities and directions for innovation. These bodies have a focus on priority setting, information sharing, and facilitating some degree of coordination across entities. They rarely carry a mandate to allocate resources and exert control.

The *Commonwealth Science Council* has been established by the Australian Government to be responsible for providing advice to the Prime Minister and other Ministers on science and technology issues facing Australia.

A key role of the Council is to advise the Government on a strategic and whole-of-government approach to all aspects of science, technology, engineering, mathematics and innovation.

The Science Council's membership is constituted by the Prime Minister, the Ministers for Industry, Education, and Health, the Chief Scientist (Executive Officer), five scientists or educators, and five business representatives. It meets twice a year.

The *National Science, Technology and Research Committee* (NSTRC) is an officials level body with responsibility for supporting the work of the Science Council.

Issues to consider

- *Is the concept of a National Innovation System useful for policy as distinct from reporting, purposes? Is it more useful to think in terms of ecosystems and clusters?*
- *Is the governance of the Innovation System excessively complex? Can the Science Council and the NSTRC engage effectively across industry and the research community?*
- *Are there any examples where regional ecosystems are doing this well? Inner Sydney, SE Melbourne, Hunter, North Ryde, Kelvin Grove, Canberra, for example?*
- *Is there a need for greater coherence in the roles, responsibilities, and accountabilities of governance institutions in the Innovation System?*

3 Investment in science, research, and innovation

Australia's Innovation System is increasingly being interpreted as a Science, Technology and Innovation (STI) system. This may underplay the contribution of other areas of research and other industries.

Strategic science and research priorities

The Chief Scientist has proposed eight national research priorities that are intended to align areas of research excellence with Australia's industrial strengths, comparative advantages, community interests and global trends. These have been discussed at the Science Council.

Box 2: Strategic Science and Research Priorities

1. **Food**: Optimising food and fibre production and processing
2. **Soil and Water**: Improving the use of soils and water resources, both terrestrial and marine
3. **Transport**: Boosting Australian transportation capacity and capability
4. **Cybersecurity**: Improving cybersecurity for individuals, businesses, government and national infrastructure
5. **Energy and Resources**: Supporting the development of reliable, low cost, sustainable energy supplies
6. **Manufacturing:** Supporting the development of high value and innovative manufacturing industries
7. **Environmental Change**: Mitigating, managing or adapting to changes in the environment
8. **Health**: Improving health outcomes for Australians.

The priorities are to some extent implied in existing patterns of research investment and expenditure by business, universities, and government. They loosely

align with the five industries identified under the *Industry Growth Centres Initiative.*

Cutting across, or through, the strategic science and research priorities are a number *key enabling technologies* (KETs) including, but not limited to nanotechnology, micro/nanoelectronics, semiconductors, advanced materials, photonics, analytics, artificial intelligence and biotechnology.

Building capability in these areas has been an important part of Australia's investment in national research facilities. It is not clear how priorities in these areas are addressed.

Government support for science and innovation

Budget tables released by the Department of Industry and Science in August 2015 indicate that In 2015-16 the Government plans to provide $9.7 billion in support of science, research, and innovation. This compares with $10.1 billion in 2011–12 and $6.7 billion in 2007-08. The major components of expenditure are set out in Tables 1 and 2 in the Attachment.

Table 1 indicates that over the four years to 2015-16 there has been a slight shift in funding priority to 'researcher driven' programs, including ARC grants and performance based funding and for rural research. Over the same period expenditure on CRCs has fallen, as has expenditure on energy and environment.

The implied broad research priorities, according to the purpose of expenditure contained in Table 2, are in industrial production and technology (21.6 per cent of expenditure), health (12.3 per cent), Energy (8.2 per cent) and agriculture (6.5 per cent).

In 2012-13, according to ABS estimates, the Commonwealth incurred expenditure of $2.3 billion through its own budget-controlled entities (including CSIRO, DSTO, ANSTO, AIMS, and Geoscience Australia). Details are provided in Table 3 in the Attachment).

ABS data also indicates that the State/Territory governments allocated $1.4 billion to R&D in 2012-13. A total of 40.1 per cent of expenditure was in agriculture, a further 34.7 per cent in health, and 15.8 per cent in the environment. Manufacturing R&D stood at 0.5 per cent of expenditure.

In July 2015 CSIRO launched *Strategy 2020* as a blueprint for Australian industry to develop, innovate and compete. It outlines how the organisation will become a global collaboration hub and help boost the country's innovation performance.

Business investment in research and development

In 2011-12 businesses invested 18.3 billion in research and development, up from $15.0 billion in 2007-08. Investment is heavily concentrated in the mineral resources and energy sector, which accounted for 27.9 per cent of research, down from 28.4 per cent in 2007-08. Research in manufacturing accounted for 24.9 per cent, down from 30.9 per cent in 2007-08.

Offsetting the decline in manufacturing R&D is a significant increase in R&D in commercial services and tourism (20.8 per cent in 2011-12) although there has been a decline in the amount and proportion of ICT investment.

Commercial services and tourism is becoming increasingly knowledge intensive, technology enabled, and internationally focussed. This is being seen in banking and financial services and professional services, for example. After a shaky start Australian owned banks, are increasing their global focus through innovation in systems and technologies and service delivery. These innovations contribute to national productivity improvement.

Table 4 in the Attachment provides more information on the distribution of business expenditure on R&D.

University research investment

The ABS estimates that in 2012 Australian Universities allocated $9.6 billion to Research and Development. Between 1992 and 2012 there has been a marked shift in the emphasis of research activity away from pure basic research, which declined from 40 per cent of the total in 1992 to 24 per cent in 2012. By contrast, applied research activity has increased from 30 per cent of research to 35 per cent of the same period. These trends are indicated in Figure 1 in the Attachment.

Research in Australian universities is heavily concentrated in medical and health sciences, which accounts for 29.4 per cent of total higher education R&D. Funding is strongly supported by the National Health and Medical Research Council as well as the Australian Research Council. A new medical research fund was established in the 2014-15 Commonwealth budget. Detailed expenditure information is provided in Table 6 in the Attachment.

Expenditure in the science, technology, engineering and mathematics (STEM) disciplines made up 43.2 per cent of research expenditure in 2012. Research in humanities, arts and social sciences (HASS)

disciplines represented 27.4 per cent of research expenditure.

In terms of the socio-economic purpose of expenditure, 34 per cent of university research is allocated to health, 9.6 per cent to the environment, 5.7 per cent to cultural understanding, and 5.6 per cent to manufacturing. More detailed information is in Table 7 in the Attachment.

Universities source most of their funds for research from internal sources, principally student fees. In 2012 this proportion stood at 56 per cent (having fallen from 64 per cent in 1994).

Commonwealth competitive grants provided 19 per cent of funds and other Commonwealth programs contributed 15 per cent. Business funding for research, at 4.5 per cent of total research funding in 2012, is generally regarded as being very low. Trends are illustrated in Figure 2 in the Attachment.

The Australian health industry has benefitted substantially from the high concentration of university research in health. There are strong collaborations between universities, medical research institutes, public hospitals, global pharmaceutical companies, and early stage venture capital investors.

Many of Australia's celebrated commercialisation successes are in the health sector – ResMed, Cochlear, Gardasil, Sirtex, Universal Biosensors, Mesoblast and Monash IVF.

Issues to consider

- *Is the allocation of $9.7 billion in public sector resources for science and innovation allocated in the best way to meet national research and innovation needs and priorities?*
- *What is an appropriate balance between resourcing for investment in Research vs. Development vs. Commercialisation? How could the balance be altered?*
- *Is the decline in ICT investment a matter of concern given its role in innovation across the Innovation System? How could this be changed?*
- *What is meant by a greater focus on industry driven research? What industries should receive greater priority?*
- *What can be done to lift Australian business support for research in universities?*
- *Are there any potential lessons for other industries from the high investment in health research and industry outcomes?*
- *Should universities be encouraged to shift emphasis in research towards industry driven requirements and away from public sector orientations? How could this be done?*

4 Education and skills

The Chief Scientist and the CEO of the Business Council of Australia have noted: 'it will be people, ideas and innovation that underpin a successful Australian economy'. This means starting to equip students early in science, technology, engineering, and mathematics (STEM), as well as so called 'boundary crossing' or 'soft' skills like adaptability, design thinking and problem solving.

Education provides a major capability for innovation, and is one of the most important vehicles for knowledge transfer. Educated students leave university to work in innovative businesses, or establish their own start-up businesses – sometimes prior to graduation. It is therefore important to consider the university and VET education in the same framework as research as an element in the Innovation System.

Science, technology, engineering and mathematics (STEM)

International research by STEM educators has found that 75 per cent of the fastest growing occupations require STEM skills and knowledge, with employment in these occupations growing at twice the pace of non-STEM. Many of these STEM skills relate specifically to computer science and software engineering.

Enrolments in *computer science* degrees at universities peaked during the dot-com boom at the turn of this century. But despite the strong demand for graduates now, many parents of school leavers still recall the dot-com crash that led to widespread layoffs and business failures, and are not encouraging students to enter the industry.

Education linkages

Submissions to the Inquiry have drawn attention to the strong education linkages in countries that have a high innovation performance, such as Germany and Finland. Many countries and jurisdictions within the United States have established close links between their higher education (university) and vocational education segments and often make reference to tertiary education 'systems'.

A strong and diverse tertiary education *system* is critical for the creation of the necessary *talent* that underlies Innovation System performance.

Many of the submissions have drawn attention to the need for *both* university-educated professionals and VET trained technicians. It is no longer helpful to see stark contrasts between higher education and

VET in the level and types of qualifications they deliver.

There has been little attention given to required structural change in the tertiary sector or how a tertiary education system could be aligned with Innovation System objectives and outcomes. There have been efforts to strengthen the connections between higher education and VET over the last thirty years but with limited success, due to structural rigidities as well as to differences in curriculum, pedagogy and assessment.

Digital literacy

There is a widely held view that a vital part of Australia's future fabric will be in industries that can successfully adopt and apply technology. Jobs will increasingly require an ability to leverage the digital technology that underpins the modern economy. This means becoming *digitally literate*.

Digital literacy is becoming a key requirement for economic and social progress in this digital age. It is reflected not only in the industries built around traditional industrial production (manufacturing, mining, energy, transport) which are going through a process of what is often referred to as digital transformation, but also in the services sector (construction, banking, finance, health, government) and in the creative and cultural industries.

Most of the important enabling technologies being developed in research organisations and applied across industry require the application of digital technology and the capacity to develop and/or apply software, program machinery and devices, and mine very large administrative and processor generated databases.

The arts, humanities, and the social sciences (HASS)

The social sciences contribute to innovation through research and practice in the areas such as market research and merchandising (involving social psychology, anthropology, and other disciplines concerning human behaviour), economics (the understanding of the behaviour and dynamics of trade and markets), finance (business case development, demand modelling, options analysis, risk analysis), and management – which is both a discipline and a practice. Management innovations have been critically important in the development of international and multi-divisional businesses.

The humanities also contribute to innovation by being able to bring knowledge and perspectives in areas such as communication, language, culture, and history – including the history of technology. Where companies compete on the basis of brands, particularly in the fast moving consumer market segment, being able to communicate value through brand identification, recognition and placement, is vitally important for competitiveness.

Many of Australia's leaders in industry, government, and in the community sector have received formal education in arts, social sciences, and humanities disciplines. Economics, law, and other branches of the social sciences are well represented in executive roles in the Commonwealth and State public services. Management graduates are sought in the large consultancy firms and frequently associated with start-up companies.

Teaching of languages, particularly Asian languages, is emerging as a gap in the higher education system and has the potential to become serious as collaboration with Chinese businesses and universities extends.

Continuous learning

Innovation can be disruptive and people require the development of new capabilities and updating of skills as business requirements change. In this context learning is increasingly a continuous and lifelong commitment. Whilst many people take their own initiative in upgrading skills it is important that employers are supportive in the investment.

Continuous learning and engagement with tertiary education facilitates networking and mobility in the Innovation System.

Issues to consider

- *How can universities, TAFE institutions and the school system connect to lift levels of innovation in Australia by addressing STEM and specifically ICT skills, and establishing an appropriate mix of hard and soft skills?*
- *Would a more integrated post-secondary education and training environment facilitate the delivery of academic and occupational learning?*
- *Does innovation policy underplay the important role of arts, humanities, and social sciences in the Innovation System?*
- *How can digital literacy be given a higher priority in education, training and awareness across the Innovation System*?

5 Innovation and industrial transformation

The Inquiry received 29 submissions from business organisations. These were heavily concentrated in

information and communications technology sector (7), industrial production (8), and biotechnology (10). There were two submissions from services businesses and one from an energy business. There were also 20 submissions from industry associations. These submissions raised a number of specific Innovation System issues that were raised in each of the submission categories.

The transformative role of ICT

ICT has a transformative role across all industries. On its own, ICT makes up only five per cent of the economy. But its influence is much more pervasive. It is an important enabler of innovation and influences all aspects of the innovation process. It makes a major contribution to productivity growth.

Across industry *digital prototyping, information modelling and analytics* enables firms to invent, design, build, deliver, and support products and projects faster, better and more economically, efficiently and effectively.

Products and projects are defined using software tools, creating a 'digital thread' that is maintained throughout the entire lifecycle - from inception, through design, scheduling, manufacturing, customer support, to end of life. Digital modelling is being applied in designing solutions in the services sector.

Small and medium businesses, which are at the core of the Australian manufacturing, construction and service industries, have been slow adopters of digital technologies. This is often due to lack of awareness, firms' cultures and traditions (particularly in family owned businesses) lack of expertise, and IT hardware and software cost.

These barriers are dropping as software vendors offer more affordable solutions, as well as cloud-based offerings that do not require an IT infrastructure to operate them. But the cost of software acquisition and installation can still be expensive and possibly financially prohibitive for small businesses, particularly if training is required.

The Australian Government does not have a digital transformation policy or strategy. The newly established Digital Transformation Office is focussed on Australian Government departments and agencies and does not have a general industry innovation or transformation mandate.

Towards the 'new' manufacturing

With digital technologies the manufacturing industry has been undergoing significant and far reaching change. Over the last 15 years the industry has transformed from a machine (industrial) basis of operation to a software and digital basis. There is a concern that we are losing our capacity to 'make things'.

The reality is that *making things* has become a lot more complex than the image of an industrial assembly line (even if it is populated by robots). Making things involves the input of value added *services* created in a broad range of complementary industrial categories. These can be highly specialised and 'knowledge intensive'. A 'manufacturer' may now be entrepreneur, a 'brand manager', or an 'integrator' that does not actually own any physical capital.

Supply and distribution arrangements are also changing as manufacturing businesses increase their participation in complex global value chains and establish coalitions (collaborations) with a range of contractors and business partners. These include innovation providers, such as software companies, professional specialists, universities and research organisations. The capacity to collaborate is recognised as a major source of competitive advantage.

Many existing and new Australian manufacturing businesses are adopting an *advanced manufacturing* approach. This means high-tech production systems, processes, plant, and equipment.

Advanced manufacturing involves the application and coordination of information, automation, computation, software, sensing, and networking, and/or making use of cutting edge materials and emerging capabilities enabled by the physical and biological sciences. Advanced manufacturing has the potential to revitalise Australian manufacturing.

Biotechnology

Biotechnology is an enabling and transformative technology that has substantial application across a wide range of industries – but specifically in pharmaceuticals and health services, animal and plant production and food.

Application of biotechnology-based discoveries in the treatment of diseases and medical conditions also provides scope for reduction in health care costs.

Biotechnology in Australia has benefited from the targeted funding of the NH&MRC and the Rural RDCs. These organisations are in a position to take a strategic approach to research investment in the health and agricultural industry sectors.

Medical biotechnology funding has enabled major scientific breakthroughs and translation into clinical products, devices, and services. Animal and plant biotechnology funding has enabled major advances

in veterinary procedures and on farm practices, though animal welfare remains an issue.

Many see the future of health and biomedical research in cluster arrangements, but these arrangements take time and continuing resource commitments to mature. The University of Melbourne, the Parkville Medical Research Institutes, and the Victorian Government initiated Melbourne's Bio21 cluster in 2000. It is now regarded as being in an important developmental phase.

Design and creativity

Technology is not necessarily a differentiator in many industries—differentiation occurs in design, creative content, marketing, and distribution channels, which establish an ability to secure a mass customer base or audience. Design is not something that is separate to technology, but is integral to it.

Historically there has been a close relationship between design and engineering in manufacturing, construction, transport and communication, and other goods producing industries. Design and creativity is also digitally enabled, with architecture, industrial design, film, video, and photography, being digitally intensive.

The Commonwealth does not have a design policy and responsibility for policy falls between several portfolios. This is a significant gap in Innovation System capability. In many ways, design and creative practice is an 'enabling technology' across all industries.

Recent Government initiatives

The *Industry Growth Centres Initiative*, announced in early 2015, is the centrepiece of the Commonwealth Government's new industry policy direction and part of the Industry *Innovation and Competitiveness Agenda*. The Growth Centres are:

- Advanced Manufacturing
- Food and Agribusiness
- Medical Technologies and Pharmaceuticals
- Mining Equipment, Technology and Services
- Oil, Gas and Energy Resources.

The Agenda aims to lift competitiveness and productivity by focusing on areas of competitive strength 'to help Australia transition into smart, high value and export focused industries'.

In June 2015 the Minister for Industry and Science announced support for the *Innovative Manufacturing CRC*. The CRC aims to bring industry into clusters together with world-leading research capability to develop new technologies, and create new products, processes and business models.

The Victorian Government has established a $200m Future Industries Fund to 'support high growth, high value industries that are critical to Victoria's future as a competitive, innovative, and outward looking economy'. The industries are: Medical technology and pharmaceuticals, New energy technology, Food and fibre, Transport, defence and construction technology, International education, and Professional services.

Similarly the Queensland Government has recently announced a $180m plan to 'create the knowledge based jobs of the future'.

Issues to consider

- *To what extent should science and innovation policy focus on broad enabling technologies that can benefit all industries rather than on specific industries?*
- *Should the role of the Digital Transformation Office be extended from a focus on Australian Government departments and agencies to a more general industry innovation mandate?*
- *Should the Industry Growth Centres industry priorities more closely align with strategic science and research priorities?*
- *Do Governments have a role to encourage and fund digital transformation and progression to a new manufacturing environment through focused education and training in digital technologies, assistance with restructuring costs, investment allowances, and accelerated depreciation.*

6 Collaboration

As the Innovation System becomes more complex, and transactional approaches to knowledge transfer become less satisfactory as a basis for innovation, more focus is being given to ways elements of the system can *collaborate* to achieve mutually beneficial outcomes.

Collaboration between universities and between universities and business is firmly on the innovation agenda.

Changing environments

Modern universities are highly complex and diverse business enterprises. Most have been established as public organisations, but they manage very large budgets on the basis of corporate management and business principles. Several Australian universities have annual budgets approaching $2 billion.

Over the last 15-20 years the organisational model of a university has moved from a feudal type structure of a lose collection of autonomous

academic entities (clans) to a more tightly integrated 'multi-divisional' model with a high level of executive control and oversight.

Universities now operate in a framework of plans, strategies, budgets, and accountability. This change has been associated with changes in the method of financing university activity.

Individual academics are now much more accountable for the way they use their time and for their performance in relation to the core mission. Their workload is governed by enterprise bargains and performance agreements negotiated with Deans and Directors of Research Centres.

Over a similar period there have been changes in the way businesses commit to R&D, combining outsourced and globally distributed approaches. R&D leaders compete with other capital expenditure priorities. Companies are looking harder at building collaborations with other businesses and the research sector.

SMEs are constantly under business pressures, including management of cash flows. They have interest in collaboration but tend to be focussed on product developments and process improvements that can be adopted and applied quickly.

SMEs generally have limited resources to pay for externally sourced research and development. They tend to be highly critical of academics who seem be only interested in 'publishing papers' and generating research income.

Collaboration capability

While the importance of collaboration has been well made, and well argued, comparatively little attention is given to the structures, rules, relationships, policies, systems, and processes under which collaboration between universities and industry can be developed and maintained.

Australian businesses tend to have a short-term transactional view of 'collaborating' with universities almost to the extent that they see a university as an outsourced R&D laboratory. At the same time, academic staff tend to see businesses as having short-term motivations and interests, and unwilling to take hard decisions about the future.

Too often, companies pursue collaboration with university researchers in an *ad hoc*, piecemeal manner, led by individual initiatives rather than any corporate strategy. But, by giving more thought to the relationship structure, companies could achieve better results. Building *trust* is a key consideration.

Successful collaborations are built around *engagement,* which reflects a concordance with the different missions of a business organisation and a research organisation. Apart from CRCs and Industrial Transformation Research Hubs and Training Centres, there has been little attention given to the development of a range of collaboration models in Australia that are fit for purpose.

Motivations, incentives, and support

There are currently few incentives for, and recognition of, researcher engagement with industry. Researchers with teaching responsibilities work in very a crowded work schedule - exacerbated by falling levels of funding (efficiency dividends) and the deterioration of staff-student ratios.

University missions, conditions of academic appointment, periodic performance assessment and a quest for tenure, mean that research active staff have a high, almost exclusive focus on the preparation of scholarly publications.

Many universities have created senior executive positions with responsibilities for industry engagement and faculties have introduced positions of Associate Dean (Industry Engagement) to provide support in building collaboration. Funding for these roles is, however, severely constrained.

There are a number of relatively small enterprise development programs designed to improve collaborations between business and universities. Many have a strong *transactiona*l orientation. There is also a lack of seamlessness between different programs offered by different agencies.

Unlike the UK, Australia does not have a system of 'third stream' funding to build collaboration capability in universities. Systemic support to build *industry engagement* capacity for collaboration should be considered.

Issues to consider

- *Could universities be more effective in communicating their changing business model of research and teaching organisations operating in a globally competitive higher education industry?*
- *Should the ERA assessment process be adjusted to include metrics that recognise the value and impact of industry collaboration? What form should these metrics take?*
- *What initiatives can be put in place to build greater trust between the businesses and university sectors?*
- *Should the current range of government incentives for business-university collaboration be developed into a strategically driven third stream funding program that aims to build capacity and capability for collaboration?*

7 The role and significance of start-up businesses

The ABS reports that in 2013-14 there were 2,100,162 businesses operating in Australia of which 284,153 were established during the year. These businesses are, in aggregate, substantial employers. There were also 263,657 business 'exits' during the year[1].

A few of these new businesses are technology start-up companies that develop and market new discoveries and 'disruptive' technologies. There are two broad categories of start-up businesses.

Venture backed start-ups

Reported data indicates that only 67 Australian companies received venture capital/private equity funding during 2013-2014. Not all of these would have been new businesses, or start-ups. The average size of investment size was $25 million in 2013-14[2].

The prototypical start-up that flourishes in the venture capital setting has a technological solution to a mass problem – or opportunity. It produces something that has a high selling price, high margins and an expectation of being profitable in two to three years. Only a small number of new technology businesses, including those that are developing mobile applications, can meet these criteria.

The 'Silicon Valley' type venture capital backed start-up does dominate in some fields, such as e-commerce and social media, where new companies have to invest significant capital before they realise any revenues. But in most fields, the well-funded and carefully planned start-up is the exception. But discussion of venture capital, what it is, how to get it, and how to spend it, dominates conversations around innovation and entrepreneurship.

Despite many initiatives Australia has not yet developed a robust early stage venture capital financing sector.

Entrepreneurial start-ups

In the US only seven per cent of the *Inc. 500* fast growing companies are venture backed, with just two per cent in the general small-business sector. The vast majority of the fastest-growing private companies are 'bootstrapped' – developed with minimal capital and following organic growth patterns.

Sixty per cent of *Inc. 500* CEOs launched their first companies with less than $10,000. A similar pattern emerges when looking at the Australian *BRW* fastest growing companies. The most noteworthy businesses quite often have somewhat unremarkable beginnings. Funding often starts with modest personal funds and ongoing financing sourced from cash flow or trade creditors.

The reality of bootstrapped businesses is that entrepreneur owners have a dedication to selling something of value to a customer. They may attract small amounts of equity funding from 'angel investors' who take an interest in the business and the vision, passion, and business capabilities of the entrepreneur.

Some entrepreneurial start-ups receive funding support from Government entrepreneurial programs, but many avoid these because of application and compliance costs. Successful entrepreneurs tend to look to *customers* to finance business growth.

Incubators and accelerators

Start-up success often happens within a supportive community. Expertise is shared, failures are dissected and then celebrated, and inspiration is easy to come by. Coworking spaces, incubators and accelerators across Australia provide environments where promising start-ups are supported.

Australia does not have a national system of business incubators or a framework to support collaborative innovation for new technology and entrepreneurial firms. But global corporations are supporting incubator models as a way of accessing technological innovations.

In 2013 Telstra launched muru-D to provide early-stage technology entrepreneurs with mentoring, tailored acceleration services, investment finance and office space. Its goal is to help Australia and SE Asia become a centre of digital business.

Issues to consider

- *Is it possible to establish a viable and credible early stage venture capital financing sector in Australia?*
- *Do we have a good understanding of growth patterns in Australian companies that commenced as 'entrepreneurial start-ups'? How can information and knowledge be effectively disseminated?*
- *Are publicly funded enterprise development programs appropriately targeted at finding and supporting genuine entrepreneurs?*

[1] ABS http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8165.0Jun%202010%20to%20Jun%202014?OpenDocument

[2] http://www.businessinsider.com.au/its-been-a-massive-year-for-venture-capital-in-australia-heres-what-happened-2014-11

8 Innovation and management practices

Australia's productivity performance will depend ultimately on the innovation capacity and performance of firms and organisations. Research has shown that the quality of management practices has a measurable impact on labour productivity, as well as sales and the number of employees in firms.

Governance

The role of boards and board leadership in innovation is sometimes overlooked. Discussions about corporate governance have tended to focus on compliance and the management (elimination) of risk. In both large and small companies the role of the board extends much further than taking a decision about hiring and firing a CEO and endorsing plans that are put to them.

Boards and CEOs are often considered to be too risk averse and excessively influenced by stock market analysts and risk averse non-executive directors. It may be necessary sometimes to take painful decisions to let non-performing family board members go if they are standing in the way of innovation, change and progress.

Effective boards bring a focus on innovation and strategy. Board members bring experience, industry knowledge, and international connections.

Management matters

It is often claimed that Australian business leaders lack management skills and capabilities and that entrepreneurial management capacity is poorly developed, particularly among SMEs, notwithstanding the enormous amount written about how to improve management performance.

Popular management self-help books, widely available and promoted by consultants, can be misleading and confusing. Lists of the five, seven, or ten best ways or well-intentioned parables, may sound good, but generally lack an execution and implementation agenda.

Managers require skills, knowledge and experience in key areas of *general management* - a practice and a craft that can be learned on the job, and improved through education and training.

It is not enough to be a great engineer, designer, marketer, or financial analyst – although one or two of these skills may dominate from time to time. A well-rounded, competent, and balanced general management capability is fundamental.

The role of Government

Investing in education and skills is a key requirement for those performing managerial roles now and into the future. Government can have a role not only in funding and guiding education and training systems, but also in the development of specific programs to develop management capability.

As most observers recognise, such programs must be accompanied by a fair, flexible and balanced system of labour market regulation.

A start has been made to explicitly incorporate management and leadership development into Australia's Innovation System, but there is scope for greater emphasis on the innovative and management capability of firms and organisations in fast moving local and international markets.

Smaller firms, who may face information asymmetries and resource constraints in acquiring and implementing world-class management practices should be able to access independent, competent, and objective advice about building management capacity.

Issues to consider

- *Are companies in Australia sufficiently well served by their board membership and representation? Should boards have a much greater focus on strategy and innovation?*
- *Is there a need to lift general management capability in Australian business?*
- *What is the role of universities and VET institutions in lifting management capacity and capability?*
- *How can smaller firms access independent, competent, and objective advice about building management capacity*?

9 Policy issues and options

This Section draws on earlier parts of the paper to identify a number of policy issues and options for consideration. It also draws on suggestions put forward in Submissions to the Inquiry.

Design for the future

Continuous investment in technology, innovation and people has become 'hardwired' across industry. But a focus on design is becoming more important as it becomes integral to producing goods and services that meet regulatory requirements, enhance user experience, and differentiate businesses in a competitive environment.

Design moves inventions that deliver 'functionality' as generic commodities to innovations that create product and service value. There is growing pressure from the community for buildings, bridges, and public spaces to be developed with design and end user value in mind.

Many have argued that Australia should move from a 'commodity' culture, reflected in the structure of our exports around minerals and agricultural produce to a 'design' culture that embraces creation of value for an end user. Value can be intrinsic as well as extrinsic. It means shifting the emphasis in production from lowest cost to highest quality and price premium.

Unlike our competitor nations the Australian Innovation System does not give a high priority to design and design thinking.

Designing for the Future would be addressed through embedding design-led innovation across all industry sectors.

Strategically driven research investment

Given the success of the NH&MRC and the RDCs in funding strategically driven research in the health and agriculture industries, a case could be made for the creation of separate research funding councils around the *Industry Growth Centres* - where targeted, strategic research and development is a high priority.

As Food and Agriculture is already largely covered by the RDCs and Medical devices and technology is covered by the NH&MRC, new funding councils could be established for:

- Industrial production and technology
- Oil and gas, including petroleum
- Mining and mining services.

Desirably, each funding council would be in a position to address the specific research environment relating to the industry, from an end user focus, and from the basic, strategic, applied, and translational dimensions.

Councils could coordinate investment with existing government research organisations including CSIRO, ANSTO, AIMS and Geosciences Australia and take a lead role in building collaboration strategies with industry. They could also recommend investments in major research infrastructure on the basis of a five-year plan.

Recognising the industry wide significance of ICT and digital technologies, and key enabling technologies (KETs) a separate funding Council could be formed to invest in this area. Chairs of Research Funding Councils would be expected to collaborate on strategy, priorities and program design.

Strengthening business investment in research and innovation

Innovation systems analysis shows the importance of systemic connectivity, evolving institutions and organisational capabilities. However, the predominant logic behind policy choices still remains one of addressing market failure, and the primary focus of policy attention tends to be on science and research rather than demand-led approaches.

Demand side issues concern the low level of investment in R&D by Australian SMEs. Moreover, a substantial proportion of university research is of little direct interest to industry. But it should not be the job of universities or research organisations to address this demand side problem by redirecting their resources in the absence of a robust collaboration environment.

Governments have put in place some programs to strengthen linkages, such as technology voucher schemes, which tend to have a short-term transactional orientation. Suggestions have been made to link entitlement to R&D tax incentives to expenditure on research undertaken in universities. This could assist in providing a longer-term focus and addressing fundamental research needs.

Some countries such as the US have made more use of public procurement to build local enterprise 'absorptive capacity' and to encourage technological change and innovation among SMEs. An example is the Small Business Innovation and Research program (SBIR) which allocates a proportion of public procurement expenditures for this purpose.

Businesses should be encouraged to invest in basic, or fundamental research. Otherwise there is a risk that an over commitment to applied research in universities will come at the expense of ongoing investment to build, maintain, and renew foundational (basic) research, enabling technologies and leading edge teaching capability.

An integrated tertiary education system

Both the higher education and the VET systems play key roles in the Innovation system in terms of educating professionals and training technicians. Increasingly employers require both professional and technical capabilities and skills. Submissions suggest that it is therefore time to think about a more integrated approach to the delivery of tertiary education.

The VET sector applies research outcomes, knowledge and ideas and trains students who directly use this knowledge in their trades and professions. The current skills shortage is in segments where the VET sector has a large share of responsibility for education.

The present evolution of the tertiary education system, where universities are moving into VET, and TAFE institutes are moving into higher education is potentially wasteful of resources. An integrated tertiary education system would potentially be more efficient and effective in meeting education and skill requirements.

There are issues around the division of Commonwealth and State responsibilities for funding, regulation, and accreditation. These are currently a matter of public debate and should be addressed as a high priority.

Innovation System integration – a National Innovation Council

A number of submissions proposed a high level National Council to provide a leadership role in developing and implementing Innovation System strategy. Roles would include:

- Delivery of a more continuous and consistent approach to innovation across the whole of government (including States and Territories)
- Identifying and addressing national innovation priorities, where outcomes would have the greatest impact in mobilising the Australian Innovation System
- Undertaking technology and knowledge 'foresight' exercises which anticipate future competitive capabilities and build an evidence base for policy
- Engaging with industry and the research and education sector on innovation issues
- Promoting design as a core innovation capability across all industries, the public sector, and the NGO sector
- Improving policy alignment and consistency within the system
- Informing and advising research funding councils, industry growth centres, and other institutions across the Innovation System.

The National Innovation Council could represent an *alliance* between the key players in the Innovation System. It would complement, not duplicate or take over, the role of the Science Council or other bodies.

One option is that the Council could be resourced through contributions from Government *and* industry with connections and information flows within and across industry sectors.

Another is that it could work on a *congress basis*, aiming to build consensus, rather than operate as a structure of committees and subcommittees trying to provide oversight and direction.

This consensus approach could provide a way of bringing together the very diverse and largely autonomous entities with roles and responsibilities in the Innovation System. It would also inspire confidence in the vision and strategy for implementing measures to strengthen innovation capability and performance.[3]

[3] UTS Adjunct Professor John H Howard assisted with research for this issues paper.

Attachment: Summary data on research and development investment

Commonwealth investment

Table 1: Commonwealth Government programs for science and innovation 2007-08, 2011-12, 2015-16

Portfolio / Activity	2007-08 $m	% of Exp.	2011-12 $m	% of Exp.	Budget 2015-16 $m	% of Budget
Australian Government research activities (CSIRO, DSTO, ANSTO, other)	1,639.3	24.4%	1,770.4	17.5%	1,805.5	18.6%
Business Enterprise sector (R&D tax measures, business programs)	1725.7	25.7%	3367.2	33.3%	3161.1	32.5%
Higher Education sector *(ARC grants, Performance funding, and other)*	1970.9	29.3%	2760.8	27.3%	2828.0	29.1%
Health (NH&MRC grants and other)	621.9	9.3%	1,078.3	10.7%	904.0	9.3%
Cooperative Research Centres	211.9	3.2%	165.5	1.6%	146.7	1.5%
Rural RDCs and other Rural	231.5	3.4%	270.3	2.7%	304.5	3.1%
Other	*234.0*	3.5%	*482.8*	4.8%	*204.2*	2.1%
Total Australian Government support	6,718.7	100.0%	10,109.4	100.0%	9,717.0	100.0%

Source. Department of Industry and Science, *2015-16 Budget Tables*, August 2015

Table 2: Commonwealth Government programs for science and innovation 2007-08, 2011-12, 2015-16by reported socioeconomic objective

Socio-Economic Objective (SEO)	2007-08 $m	% of Exp.	2011-12 $m	% of Exp.	Budget 2015-16 $m	% of Budget
Exploration and exploitation of the Earth	417.8	6.2%	576.0	5.7%	423.1	4.4%
Environment	195.0	2.9%	334.0	3.3%	331.8	3.4%
Transport, telecommunication and other infrastructures	134.8	2.0%	498.3	4.9%	363.6	3.7%
Energy	285.3	4.2%	687.8	6.8%	797.9	8.2%
Industrial production and technology	1,773.5	26.4%	2,420.4	23.9%	2,096.1	21.6%
Health	859.5	12.8%	1,365.1	13.5%	1,196.2	12.3%
Agriculture	462.9	6.9%	554.2	5.5%	632.7	6.5%
Political and social systems, structures and processes	200.5	3.0%	593.2	5.9%	691.2	7.1%
General advancement of knowledge: R&D financed from University Funds	1,391.7	20.7%	1,774.6	17.6%	1,995.8	20.5%
General advancement of knowledge: R&D financed from other sources	381.5	5.7%	578.2	5.7%	615.5	6.3%
Defence	457.6	6.8%	529.6	5.2%	482.4	5.0%
Other	158.5	2.4%	197.9	2.0%	90.8	0.9%
Total	6,718.7	100.0%	10,109.4	100.0%	9,717.0	100.0%

Source. Department of Industry and Science, *2015-16 Budget Tables*, August 2015

Government expenditure on R&D

Commonwealth

Table 3: Commonwealth Government expenditure on R&D, by socio-economic objective, 2009-10, 2012-13

	2009-10		2012-13	
	$'000	%	$'000	%
Defence	485,783	21.6%	553,757	23.6%
Plant Production and Plant Primary Products	106,919	4.7%	162,056	6.9%
Animal Production and Animal Primary Products	52,217	2.3%	73,246	3.1%
Mineral Resources (Excl. Energy Resources)	74,656	3.3%	106,659	4.5%
Energy	139,954	6.2%	173,114	7.4%
Manufacturing	147,372	6.5%	144,116	6.1%
Construction	16,752	0.7%	10,601	0.5%
Transport	17,730	0.8%	22,302	1.0%
Information and Communication Services	146,958	6.5%	84,935	3.6%
Commercial Services and Tourism	7,730	0.3%	1,185	0.1%
Economic Framework	47,293	2.1%	55,357	2.4%
Health	138,199	6.1%	197,242	8.4%
Education and Training	4,557	0.2%	9,829	0.4%
Law, Politics and Community Services	163,698	7.3%	28,381	1.2%
Cultural Understanding	5,618	0.2%	24,431	1.0%
Environment	489,933	21.8%	552,363	23.6%
Expanding Knowledge	206,574	9.2%	144,966	6.2%
Total	2,251,941	100.0%	2,344,539	100.0%

Source: 8109.0 - Research and Experimental Development, Government and Private Non-Profit Organisations, Australia, 2012-13

State/Territory

Table 4: State Government expenditure on R&D, by socio-economic objective 2009-10, 2012–13

	2009-10		2012-13	
	$'000	%	$'000	%
Defence	221	0.0%	0	0.0%
Plant Production and Plant Primary Products	156,920	13.4%	293,032	21.2%
Animal Production and Animal Primary Products	163,652	14.0%	261,345	18.9%
Mineral Resources (Excl. Energy Resources)	29,343	2.5%	41,927	3.0%
Energy	9,269	0.8%	4,350	0.3%
Manufacturing	17,527	1.5%	6,578	0.5%
Construction	647	0.1%	1,243	0.1%
Transport	5,677	0.5%	1,101	0.1%
Information and Communication Services	9,935	0.9%	1,073	0.1%
Commercial Services and Tourism	4,982	0.4%	1,025	0.1%
Economic Framework	3,271	0.3%	8,458	0.6%
Health	405,469	34.7%	478,959	34.7%
Education and Training	11,568	1.0%	23,880	1.7%
Law, Politics and Community Services	16,300	1.4%	7,215	0.5%
Cultural Understanding	9,682	0.8%	11,026	0.8%
Environment	304,155	26.0%	217,507	15.8%
Expanding Knowledge	19,907	1.7%	22,207	1.6%
Total	1,168,527	100.0%	1,380,926	100.0%

Source: 8109.0 - Research and Experimental Development, Government and Private Non-Profit Organisations, Australia, 2012-13

Business expenditure on R&D

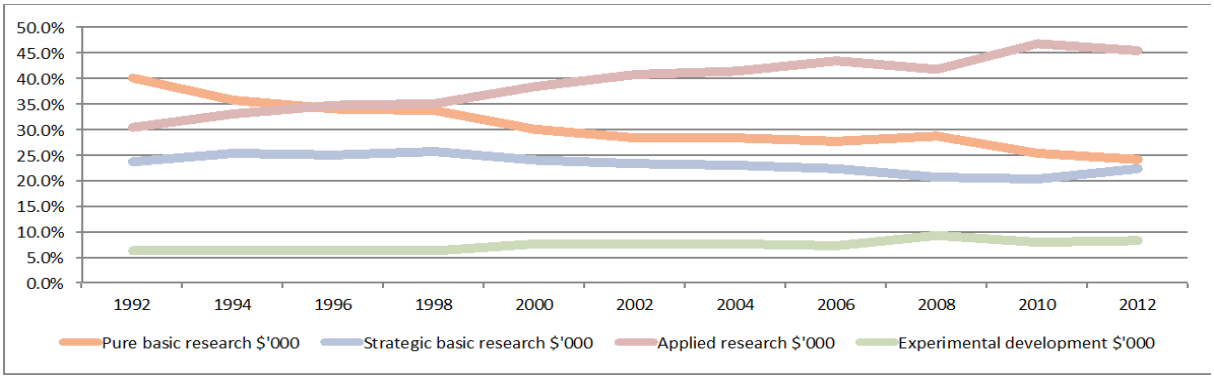
Table 5: Business expenditure in R&D by socio economic objective, 2007-08 and 2011-12

	2007-08	2007-08	2011-12	2011-12
	$'000	%	$'000	%
Defence	286,795	1.9%	197,124	1.1%
Plant Production and Plant Primary Products	178,789	1.2%	302,487	1.7%
Animal Production and Animal Primary Products	108,400	0.7%	165,619	0.9%
Mineral Resources (Excl. Energy Resources)	2,188,693	14.5%	2,742,403	15.0%
Energy	2,095,938	13.9%	2,361,179	12.9%
Manufacturing	4,642,942	30.9%	4,562,845	24.9%
Construction	903,334	6.0%	933,773	5.1%
Transport	383,932	2.6%	438,193	2.4%
Information and Communication Services	1,927,093	12.8%	1,835,591	10.0%
Commercial Services and Tourism	1,714,839	11.4%	3,809,373	20.8%
Economic Framework	31,427	0.2%	21,499	0.1%
Society	*455,041*	3.0%	*678,982*	3.7%
Environment	125,399	0.8%	228,504	1.2%
Expanding Knowledge	4,739	0.0%	43,750	0.2%
Total	15,047,360	100.0%	18,321,322	100.0%

Source: ABS 81040DO008_201112 *Research and Experimental Development, Businesses*, Australia, 2011-12, 6 Sept 2013.

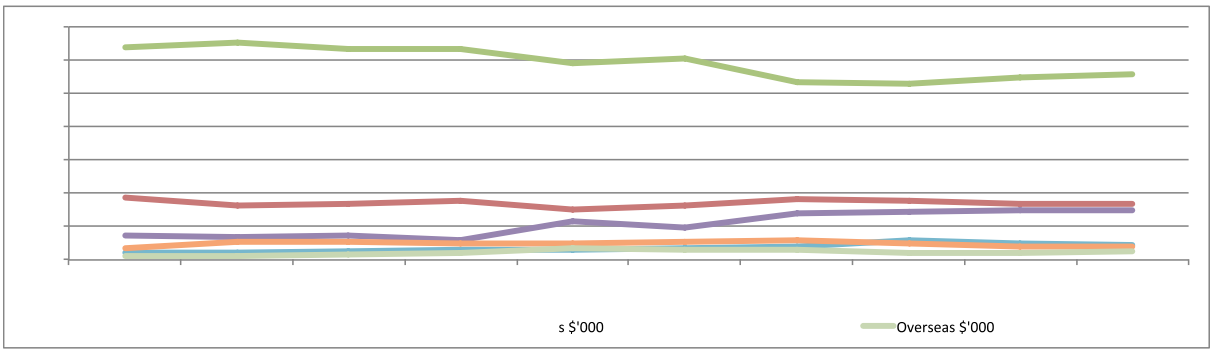
Higher education expenditure on R&D

Figure 1: Research and Experimental Development, Higher Education Organisations, Australia, 1992-2012. Expenditure by type of activity



Source: ABS, Research and Experimental Development, Higher Education Organisations, Australia, 2012, 81110DO001_2012, May 2014

Figure 2: Research and Experimental Development, Higher Education Organisations, Australia, 1992-2012. Sources of research funding



Source: ABS, Research and Experimental Development, Higher Education Organisations, Australia, 2012, 81110DO001_2012, May 2014

Table 6: Higher education expenditure on R&D by fields of research, 2008-2012

	2008 '000	2010 '000	2012 '000	2008 %	2010 %	2012 %
Science	1,985,410	2,227,891	2,701,977	29.2	27.2	28.0
Engineering and technology	1,004,299	1,269,567	1,453,674	14.7	15.5	15.0
Medical and health sciences	2,072,060	2,327,499	2,822,549	30.3	28.5	29.4
Social sciences	1,353,084	1,801,032	2,056,035	19.8	22.0	21.4
Humanities	428,671	534,882	575,502	6.3	6.6	5.9
Total	**6,843,526**	**8,160,871**	**9,609,736**	100.0	100.0	100.0

Source: ABS, Research and Experimental Development, Higher Education Organisations, Australia, 2012, 81110DO001_2012, May 2014

Table 7: Higher education expenditure on R&D by socio-economic purpose, 2008-2012

	2008 $'000	2010 $'000	2012 $'000	2008 %	2010 %	2012 %
Defence	58,715	64,067	63,233	0.9	0.8	0.7
Agriculture	303,232	316,652	423,881	4.4	3.9	4.4
Minerals and energy	225,065	374,694	469,450	3.3	4.6	4.9
Manufacturing	342,002	426,033	534,131	5.0	5.2	5.6
Construction	125,530	115,746	147,535	1.8	1.4	1.5
Transport	68,653	105,108	107,966	1.0	1.3	1.1
Information and communication services	229,474	301,798	349,976	3.4	3.7	3.6
Commercial services and tourism	103,962	166,519	174,662	1.5	2.0	1.8
Economic framework	247,838	369,088	349,907	3.6	4.5	3.6
Health	2,360,902	2,632,089	3,270,960	34.5	32.3	34.0
Education and training	294,995	355,504	404,237	4.3	4.4	4.2
Law, politics and community services	350,992	463,383	473,836	5.1	5.7	4.9
Cultural understanding	380,819	436,307	550,752	5.6	5.3	5.7
Environment	538,451	725,825	919,687	7.9	8.9	9.6
Expanding knowledge	1,212,896	1,308,057	1,369,522	17.7	16.0	14.3
Total	**6,843,526**	**8,160,871**	**9,609,736**	100.0	100.0	100.0

Source: ABS, Research and Experimental Development, Higher Education Organisations, Australia, 2012, 81110DO004_2012, May 2014